THE TELEGRAPHIC JOURNAL AND

Electrical Review.

VOL. XII.—No. 289.

SECONDARY GENERATORS.

WHEN we described the apparatus devised by Messrs. Gaulard & Gibbs, a few weeks since, we invited our correspondents' opinions on the feasibility of these "secondary generators." We publish in the correspondence columns of our present number a letter from Mr. Rankin Kennedy, which will be read with interest, and we should be highly pleased if this investigator carried his experiments still further, with a view of finding even approximately the percentage of loss which takes place when the primary current is made to do work in a secondary circuit instead of being applied direct. It may be that there are circumstances under which the use of such apparatus will be found desirable, but we do not know of any really practical advantage that these "secondary generators" offer, if we leave out of the question the regulation of the lamps by the movement of the adjustable iron core. It may be thought by some that the use of such supplementary instruments might be advantageous to a candle system, say such as the Jablochkoff, where the multiplicity of leading wires in each circuit forms a formidable item in the cost of an installation. On the other hand, it would be most interesting to know whether the cost of these "secondary generators," including the wire for winding them, would be more or less for doing a given amount of work than the leading wires referred to, over and above the usual lead and return which is requisite in any system. We cannot believe that men like Paul Jablochkoff, Professors Houston and Thomson, and Sir Chas. Bright—men who are electricians and not visionary enthusiasts—would have allowed this subject to dwindle away to mere nothingness had there been a chance of bringing the matter to a successful issue. It must be admitted that the introduction of any supplementary apparatus of the character we are speaking of, and in the manner proposed for their operation, will necessarily increase the chances of a breakdown in the circuit, and as we have before pointed out the personal danger of working with alternating currents is not by any means avoided by the employment of these induction coils, but rather increased. Still, the merits or demerits of "secondary generators" is a matter of great interest, not only to electricians, but to those commercially interested in the future of electric lighting, and the experiments of Mr. Kennedy will doubtless have the effect of inducing others to follow up the subject. That Mr. Kennedy's apparatus is an "induction coil pure and simple," Messrs. Gaulard & Gibbs will scarcely deny, nor can they deny, that the action of their particular construction of coil is identical with that of his.

London Electric Wire Company.—This company has removed from Wenlock Buildings, Ironmonger Row, to Anchor Works, Playhouse Yard, Golden Lane, E.C.

THE ELECTRICAL TRANSMISSION OF POWER.

M. CORNU'S REPLY TO M. CABANELLAS' NOTE, ENTITLED, "A FUNDAMENTAL POINT OF THEORY." *

FOR the sake of brevity I will come at once to this fundamental point. M. Cabanellas finds fault with the report for having "calculated the electromotive forces from the formulæ

$$e \quad u - rI \qquad\qquad E = U + RI,$$

in which r, R, are the measured static resistances, the ring being motionless, which is at any rate begging the question (?); but besides," continues M. Cabanellas, "our former researches have proved that if we wish to render these formulæ applicable to machines in motion, we must give to r, R, their respective dynamic values, corresponding to the actual rates of motion." I maintain that we must not substitute for r, R, the values which M. Cabanellas calls dynamic, for the result of the substitution of these resistances, which are, as he himself acknowledges, equivalent to the addition of a "counter-electromotive force," would be to suppress one of the electromotive forces, the algebraical sum of which according to definition (and this definition appears to be generally adopted) constitutes the electromotive force, E, or e, of the machines employed.

I will show this in a few words.

Let us consider a single wire conductor having a resistance, r, and an electromotive force, ϵ; we know that the expression of the difference of potential, a, at the two extremities of this conductor is:

$$a = rI + \epsilon.$$

I being the intensity of the current, we may evidently state that $a = \rho I$, representing by ρ the resistance of an ideal conductor, which when traversed by a current of the same intensity, I, would present the same difference of potential a, at its extremities.

The quantity that M. Cabanellas designates by the name of *dynamic resistance*, when he considers the Gramme ring in motion, protected against all external inductive action but traversed by a current with intensity I, seems to be exactly this quantity, ρ. When we adopt this definition we must not forget that the electromotive force, ϵ, is contained in the statement of this dynamic resistance, for, working it, out, we get

$$\rho = r + \frac{\epsilon}{I}$$

In the case of the Gramme ring, the dynamic resistance being, according to M. Cabanellas, always greater than the static resistance, the term

$$\frac{\epsilon}{I}$$

is always positive, whatever may be the direction of rotation of the ring and the sign of I; ϵ is therefore a counter-electromotive force. If we generate in this conductor, by means of an external inductive action, other electromotive forces, the sum of which should be ϵ', the difference of potential at the extremities of the conductor will be

$$u = rI + \epsilon + \epsilon' = \rho I + \epsilon'.$$

As we can find u and I directly by observation, we get the two equations:—

$$\epsilon + \epsilon' = u - rI \qquad \epsilon' = u - \rho I.$$

The first equation gives the algebraic sum of all the electromotive forces developed in the conductor; the second, in which enters the resistance called dynamic ρ, only gives the part, ϵ', corresponding to the external induction.

Let us apply these results to the ring of a dynamo, or magneto-electric machine, which, with two equidistant brushes, brings us back to the case of a single wire conductor. This ring is the seat of the two kinds of electromotive forces, ϵ and ϵ', which we have just defined. The electromotive force, e, of the ring is, by definition, the algebraic sum of all those developed in it.

$$e = \epsilon + \epsilon'.$$

We get, therefore:—

$$e = u - rI.$$

This is one of the formulæ employed in the above-mentioned report. The addition of the inductors in the case of a dynamo-electric machine would not alter the signification of any of its terms.

* See last week's ELECTRICAL REVIEW.

M. Cabanellas, when he proposes to substitute ρ for r, asks us to write the equation incorrectly $e = u - \rho I$, for the true equation given above is : $\epsilon' = u - \rho I$. The expression $u - \rho I$ does not therefore signify what is generally known as the electromotive force of the machine, *i.e.*, that which, multiplied by I, represents theoretically the energy transformed, viz.,

$$e = \epsilon + \epsilon'.$$

The expression $u - \rho I$ only represents ϵ', *i.e.*, the electromotive force developed in the ring by external induction ; it omits, therefore, the sum ϵ of the electromotive forces developed in the ring under the reciprocal action of its elements.

Consequently it expresses inaccurately the energy transformed, viz., $\epsilon' I$ instead of $(\epsilon + \epsilon')I$. We could in the same manner arrive at the demonstration of the second formula : $E = U + RI$, which only differs from the first by the sign of E and U.

It is easy to see that this suppression of one of the electromotive forces acts in a contrary manner when the machine works as a generator to what it does when the machine constitutes a receiver, and in the direction which would re-establish the equality of the transformations from mechanical to electrical energy (an equality apparently troubled in practice by secondary actions) ; in reality it increases E, the electromotive force of the generator, by suppressing the opposing electromotive force of the ring, and by the same method it diminishes e, the electromotive force of the receiver, which is naturally an opposing electromotive force ; it was probably this result that misled M. Cabanellas, by showing him a method of "completing the deficit" that these machines present. Unfortunately this method is an illusion and opposed to the first principles of the conservation of the energy, which the writer claims to verify most indisputably.

In conclusion, therefore, we may say that the correction proposed by M. Cabanellas rests upon the confusion caused by his definition of the dynamic resistance ; it is therefore useless to follow out the deductions made from it.

The calculations in the report are, on the contrary, perfectly correct from a theoretical point of view.—*Comptes Rendus.*

M. MORIN'S SOLENOID CANDLE.

In this new apparatus, which we reproduce from *La Lumière Electrique*, M. Morin has replaced the electro-magnet, such as is used by Wilde and others, by a solenoid, whose action

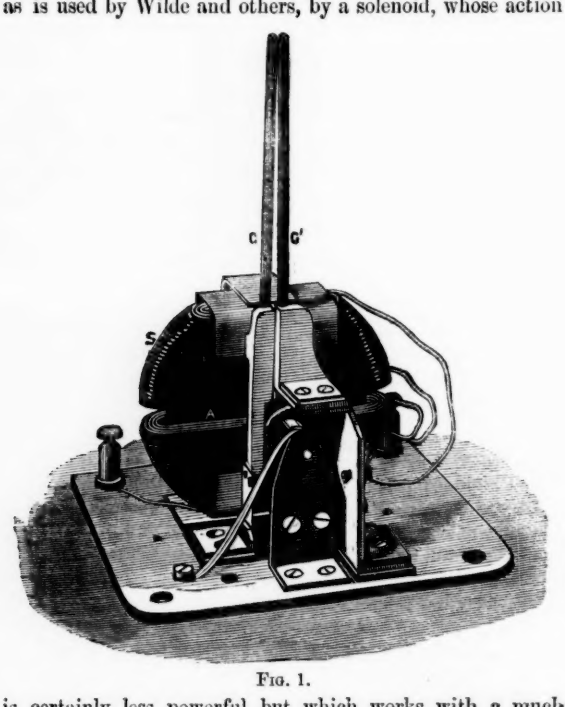


FIG. 1.

is certainly less powerful, but which works with a much shorter distance ; so that, instead of the violent and instantaneous action of the electro-magnet, we have a progressive motion which prevents the metallic vibration produced in the first case, and of which the noise was often much greater than that of the arc itself.

Figs. 1 and 3 represent the apparatus for a single candle. It will be seen that the solenoid, S, is flattened, and has almost the form of a galvanometer coil, only instead of being rectangular the internal cavity of the coil is circular ; and in this cavity is placed a plate of soft iron, A, movable around a horizontal axis.

In repose the plate, A, is slightly inclined in relation to the wire of the solenoid ; but when the current passes it tends to place it at right angles with it by turning it upon its axis.

This rotation has been utilised for separating the carbons. For this purpose an eccentric fixed rigidly upon the axis of the plate, A, serves as a cam which moves the movable carbon, C, producing the arc as long as the current passes. But when it ceases, a counter-spring restores the iron plate, A, to its original position, and the carbons become again in contact, being thus prepared for relighting.

By slightly increasing the dimensions of the apparatus ; the solenoid can be made much more powerful, and four burners may be placed upon the same apparatus, which allows a prolonged illumination without the necessity of renewing the carbons.

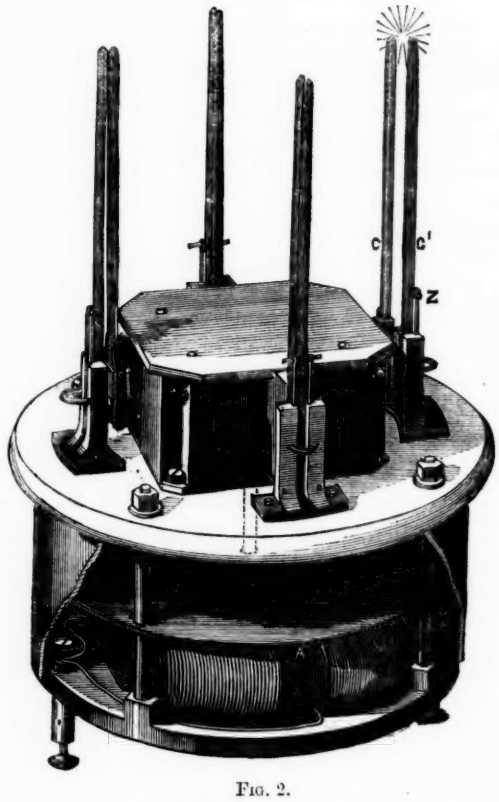


FIG. 2.

In this apparatus, which is shown in figs. 2 and 4, the solenoid, S, is placed horizontally, and the axis of the iron plate, A, is vertical, and carries at the upper end a disc having four projections which act upon four carbon-holders in the same way as the cam in the single candle apparatus ; these projections are arranged so as to act successively.

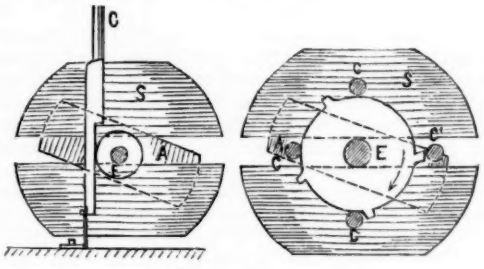
In this arrangement the light is produced as before. When the current passes, the iron of the solenoid, which was maintained in a certain position by a spring, moves in a direction transversal to that of the wire, until one projection has reached the carbon-holder of the first candle and produces the arc. On the current ceasing, the iron plate returns to its first position by an opposing spring, and the carbons come again in contact.

In order to obtain the successive and automatic lighting of the various candles, the fixed carbons are supported by a piece of zinc wire, z, which burns as soon as the arc reaches it, and the fixed carbon being no longer supported falls out ; and the arc is thus broken without altering the apparatus.

But as the circuit is still closed by the other candles which are in contact, the iron plate, A, turns until the second projection causes the lighting of the second candle ; and so on.

The change from one candle to another is very rapid and is scarcely perceptible.

In studying this new lamp, M. Morin observed some phenomena resulting from the action of the solenoid upon the voltaic arc. Thus, in a lamp in which the four candles were placed symmetrically around the axis of the plate, A, the two of them placed diametrically opposite and situated over the free space comprised between the two halves of the



FIGS. 3 AND 4.

solenoid were not affected ; in the third, situated over the middle of one half of the solenoid, the arc was slightly repelled towards the extremity of the carbons as in the apparatus of M. Jamin ; lastly, in the fourth, the arc was violently attracted towards the base, that is to say, upon the supports which would have been destroyed in a few moments.

These differences of action, which are not surprising, considering the direction of the current in the arc and in the nearest portion of the solenoid, constituted a very grave defect, which M. Morin has overcome by placing the solenoid as far off as possible and interposing a plate of iron, which, according to M. Morin, is a proof of the reality of magnetic screens.

In order to measure the work absorbed by these candles, M. Morin made use of a dynamometrical pulley, giving continuous indications, which he has constructed upon the principle of his dynamometer. He found thus, that :—

3 candles absorbed	...	...	...	3·30	H. P.
4 ,,	,,	...	...	4·16	,,
5 ,,	,,	...	...	5·40	,,

for an illuminating power of about 40 carcels.

He hopes, however, to increase this result by modifications which he has just made in the Alliance machine.

SECONDARY BATTERIES AND THE ELECTRICAL STORAGE OF POWER.

PROF. LODGE delivered his second lecture on this subject at the Society of Arts on Monday evening of last week, when Mr. W. Preece presided.

Prof. Lodge said there were one or two further experiments with the little battery before him (with which he had experimented on the occasion of his previous lecture) with which he should begin, because they really threw a good deal of light on the action of the secondary battery. He wanted to show the extreme value of peroxide of lead on the positive lead plate. For instance, let them take a piece of clean platinum and put it into the cell instead of the negative lead plate ; they had platinum on the one side, and peroxide of lead on the other, both highly electro-negative substances (experimenting). That amount of current was given by platinum opposed to the peroxide of lead, the platinum acted as zinc compared with peroxide of lead. Putting in a piece of clean copper as the negative plate they got a current which lasted longer and which was able to ring a bell. The copper plate in fact gave very considerable power and lasted fairly well. The copper was dissolved, and formed sulphate of copper. The action of the battery was over when either the copper was dissolved or when the sulphuric acid was consumed and turned into sulphate of copper. Instead of copper he would now take a piece of lead which they would imagine to be still better than copper. He put the lead in the acid ; he tried it with the current and the current was immediately over. The plate seemed done for, and why ? Because the clean lead plate had got into such a state that it would give a current neither with peroxide nor with hydrogen, neither with zinc nor with platinum ; it was, in fact, almost as if it were a piece of wood, it was coated with an insulating film. If he put in a piece of spongy lead the current would go on for a long time, so that by giving the lead a large surface, by making it spongy as might be done mechanically, chemically, or electrically, they got the negative surface so large that no scum formed on it for a long time. It was owing to the smooth and limited surface of the clean lead that the scum formed almost instantly. It was of course, however, a question of degree. Another point he wished to call their attention to was the great advantage which the inactivity of lead after the first instant conferred as a support for the peroxide. If he took a piece of clean lead and opposed it to the peroxide plate, it refused to give a current after the first instant. The insolubility of sulphate of lead, which to some extent was a trouble, was, however, to some extent a gain. The plates of which a battery was made might be spongy, or might be perforated, or might be folded. After describing how these leads were made the lecturer went on to consider the subject of meters. The means of measuring the current, he said, was nothing else than measurements made in either putting into the cell or taking out of the cell—in charging or discharging. There were meters for the measurement of current, of electromotive force, of quantity, of power, and of energy. The two first he would take as fundamental. Then quantity was current multiplied by time, current multiplied by electromotive force was power, and energy was quantity multiplied by electromotive force or power multiplied by time. He would not say anything about current measurers. Any low resistance galvanometer would act as a meter for current, and any high resistance galvanometer would act as a measurer of electromotive force. To measure the current of electricity the most direct and simplest way, in some respects, was by some such arrangement as this (showing model). He had found the instrument, of which that was a model, exceedingly valuable. It consisted of a balance suspending a copper cylinder in a vessel of copper lined by a much larger copper cylinder. He should totally immerse it in the liquid, but no more, and now he would put the current on, so that the outer plate was positive and the inner negative. The inner plate would receive a deposit of copper, and as it did it would get heavier and the balance would sink, and they should find the plate at the bottom of the cell before very long. Hence it enabled them to say how much was in the cell, because whatever had gone in had deposited copper, and whatever had come out had removed copper. Of measurers of energy or quantity multiplied by electromotive force or power there were several. Mr. Boys, he believed, had several, but not in a state of perfection. Ayrton and Perry had also their recently constructed power meter, which was very simple, and might very likely give very good results. Having previously discussed the charging and discharging of the cells, they had now to consider how to use the discharge. The first and most obvious use was lighting. The advantages of secondary battery purposes for lighting were found when the lighting was in a travelling conveyance—in a train or a ship, though in a big ship, with so much engine-power on board, they might run from the dynamo direct. But supposing they wanted to light a cab, they might carry a box with them sufficient to keep a small lamp lit. And the use of the battery for stationary installations was when they wanted a greater power than their engine would give. That especially applied to cases where they used steam-engines. It did not pay them to let an engine lie idle all day and have it working at night only ; it was better to have it running regularly. And when they wanted to use the light, having stored it up in secondary batteries, they could run it off at a high rate of speed and thus increase the power of the steam-engine, compressing its total energy into smaller compass, and at the same time they gained in security, because the batteries once charged were not quite so liable to break down as a belt was to slip. A third advantage of the secondary battery was the steadiness with it produced the light. (The lecturer here showed this by the lighting of several Swan lamps and also a Pilsen arc lamp in the hall.) There was nothing new in the lamps, but they shone with absolute steadiness, there being not a sign of fluctu-

ation about them. That resulted from lighting from the battery direct. They might put out any of the lamps without interfering with the others, and that was not so easily done with dynamos. One great use of storage batteries, which was pointed out by Sir William Thomson at the British Association meeting at York, was to have them act as receivers in the transmission of energy. The theory of the economical transmission of energy was worked out practically by Dr. Siemens a few years ago. He pointed out that for economy they must have as high electromotive force as possible. A set of batteries as a receiver was far more economical than a set of dynamos. An economical force from a dynamo could only be obtained by running it at an enormous speed. There was a certain limit, however, to that speed, and if they wanted an excessive electromotive force they must have a fair internal resistance. The more suitable machines were those which gave a high electromotive force. Then they came to the driving of motors by the secondary battery. It would be found an advantage when the secondary battery received the power from a distant station. A motor was the same as a dynamo, except that the field-magnet in a dynamo was much smaller and more compact. There was no limit to the size of the field-magnet, but there was to its weight. The reason why the Edison machine was such a good machine was because the magnet was so gigantic. If they considered the action of a magnet when it was excited, they would perceive that all that the current was doing was to generate heat. There was a remarkable analogy between the production of magnetism in iron and the muscular exertion of an animal. To raise the magnet to its highest power required work, and to keep it there required work. It would be a great advantage if the iron would keep the magnetism. Profs. Ayrton and Perry had lent him a motor* (exhibiting motor), and the peculiarity of that instrument was that the field-magnets revolve instead of the armature (experimenting). Motors were by no means perfect at present; there would be an immense development in them yet. Coming now to locomotion. If they were to have a railway driven by such means the simplest plan would be to attach a motor to each wheel of the carriages, they would then be independent of an engine. In that case he thought it would be more convenient to have a carriage run from a station every minute than a train every five minutes. He did not say the running of a carriage every minute would suit the Underground Railway, considering there were so many trains there already; but there would be an enormous advantage in their having the trains run there by means of electricity, and it seemed to him absurd to put coal-burning locomotives on the underground railways when this system could be readily adopted. The dynamo, again, was so exceedingly well suited to a small screw boat that he could not help thinking that there was a great future for the dynamo in marine propulsion. The weight of the dynamos for big ships would be too heavy; but he doubted not but that some means would yet be found to make them lighter. For a central station, however, the weight of the battery boxes was of no consequence. The practical development of electrical appliances in the near future he felt would probably be something extraordinary, and he only hoped they would have as great a social influence as they would have a mechanical. He also trusted that the result would be the abolition of smoke and the purification of the air. A greater benefit to society than that he for one was unable to imagine.

On the motion of the chairman, a hearty vote of thanks was awarded to Prof. Lodge for his lectures.

* See our "Correspondence" Columns.

The Board of Trade and Professor Tyndall.—There was issued, on Friday of last week, a Parliamentary paper, obtained upon the motion of Mr. Gibson, giving the correspondence on the proposed investigation of the respective merits of gas, oil, and electricity as lighthouse illuminants, including the letters which passed between the Board of Trade and Professor Tyndall regarding the circumstances attending the latter's resignation of his position as Inspector of Irish Lighting Apparatus.

INVENTORS AND INVENTION.

(A COMMUNICATION.)

THAT "there is nothing new under the sun" is an adage which, accepted with due qualifications, is as true as it is trite. All inventions, even the most grand and startling discoveries which have created quite a revolution in the scientific world, have been arrived at by a gradatory process —by a series of progressive steps from the crude conception of the original idea to its complete and practical development. It is only necessary to instance in support of our statement such familiar examples as the steam-engine, the telephone, and the electric light; not one of which truly wonderful inventions started into useful life and vigour at once, but all were gradually matured from the embryonic suggestion to the full-grown and perfectly-developed being. This fact should teach us to be thankful for small mercies, and not to despise or disparage the weakest suggestion because it is such a slight advance on the knowledge which has preceded it. Every invention and discovery is but a step—and frequently a very short step—in the march of improvement, whether the inventor himself realises this truth or not. Inventors, we know, for the most part, have a tendency to magnify the importance of their discoveries, and appropriate to themselves a larger share of the credit of novelty than is their rightful due, and it requires the wholesome correcting influence and cool impartial judgment of a practised independent mind to reduce the invention to its true proportions, and assign to it its proper place in the scale of improvement. It does not, however, follow that because a person has been to a great extent anticipated in his ideas that he is any the less a genuine inventor. His mind has been the subject of that train of reasoning which results in the evolution of an invention, and it is no disparagement to him that another person has trodden precisely the same ground before him, although this fact does of course detract from the value of his labours.

The concurrence or coincidence of invention in different individuals is a matter of every day occurrence, and it has frequently called forth expressions of surprise that two men who could not have been in connection or collusion should have found their way into the same track; but when we reflect that the human mind is similarly constituted in all men and that there are only a limited number of ways of effecting an object, it is not an occasion for astonishment that persons of equal knowledge and attainments who have been working in the same direction should sometimes or often arrive at the same result.

A question which is sometimes raised—perhaps more curious than useful—is whether invention is a natural gift or purely the result of well-directed study and experiment. One inclines to the opinion that inventions as a rule are the product of men of what is termed an inventive turn, although no doubt the "gift" of invention, like other faculties, may be improved by exercise. While, therefore, considering that a natural bent or bias is necessary to make the genuine inventor, one would by no means be understood as endorsing the sentiment conveyed in the somewhat inelegant expression which has been attributed to Sir William Armstrong, viz., that "inventors can no more help inventing than hens can help laying eggs." I do believe that some genius is necessary to make the successful inventor, but I as fully believe that that genius must be supplemented by the exercise of great mental energy, or without this dint of industry, despite all his talent and capacity, the field will yield but a meagre crop.

One would advocate, then, the utilisation of every available aid to invention, such as a highly cultivated and well balanced mind, general scientific knowledge, and a special and experimental acquaintance with the particular subject to which the would-be inventor is directing his inquiries, without, however, lending an adherence to every chimera which is vaunted as an aid to invention.

Some persons affect to believe that a life of celibacy is favourable to invention, and, indeed, to the exercise of any high order of mental employment, and they profess to explain the alleged fact on physiological principles. When, however, recalling to mind the long list of names of men in conjugal relations who have distinguished themselves, not only as inventors, but in every field of investigation and research, I do not think that Hymen has much to fear from

the teachings of those who take so heteorodox a view of the advantages or disadvantages of the marriage state.

Others assert that, as in mental exercise generally so in inventive inquiry in particular, diet plays an important *rôle*. Now in this statement one feels more disposed to acquiesce. One thing is quite certain, that while, as has been well observed, good digestion and mental power are not synonomous terms, yet good work of the kind requiring any effort of mind is almost an impossibility when the individual is in a dyspeptic condition. Further than this, there can be no doubt that the power of mental application may be increased or diminished according to the nature of the food taken. We are all familiar with the adage, which is almost accepted as a truism, that "there is no thinking without phosphorous," but without endorsing the statement that this element is essential to brain power, we may safely assert that the character of our work is very much influenced by the kinds of food of which we partake. This subject which has only recently been investigated, and is still but imperfectly understood, is one of the highest importance, and its careful study cannot be too strongly urged upon brain-workers generally and particularly upon those who are by profession inventors. Experience has demonstrated over and over again that the whole bent and bias of the mind, the affections, and the passions are influenced by a change of diet and regimen—a studious habit or an indolent propensity, courage or pusillanimity, love or aversion, a disposition for society or a yearning for solitude being induced according as one viand or another forms the staple of our diet. It is fair, therefore, to assume that when the matter has received the attention it deserves, we may be enabled, by adapting our food to circumstances, to call forth any particular power or faculty of the mind into activity at will, and thus direct our efforts to the best advantage.

I have but imperfectly touched upon this subject, but have probably said enough to show that if invention be a natural gift there are at any rate aids and auxiliaries, by availing ourselves of which that gift may be improved and the maximum of benefit secured from the exercise of the inventive faculties.

T. J. HANDFORD.

THE DIRECT AND DERIVED FIELD-MAGNET CIRCUIT IN THE DYNAMO.

(A COMMUNICATION.)

THE question as to whether a dynamo works more economically with its field-magnet in derived than in direct circuit has often been brought forward, and several arguments in favour of one or the other of these methods of connecting the field-magnet have been advanced; but I find that if certain rules are observed in the winding of the coils of the dynamos that both methods are equally economical. Let two dynamos be equal in size and have equal weights of wire on the two field-magnets and the two armatures, the wire being, however, of different gauges. Let L equal the resistance of the exterior circuit, R and r the resistances of field-magnet and armature of dynamo with its field-magnet in direct circuit, and R_1 and r_1 the resistance of the field-magnet and armature of the dynamo with its field-magnet in derived circuit. Then when the magnetic field was constant the current generated would vary as the length of the wire on the armature directly and as the resistance of the circuit inversely, and since the length of a certain weight of wire varies as the square root of its resistance the length of the wire on the armature would be equal to

$$\sqrt{r}$$

and the current generated by the dynamo with its field-magnet and direct circuit would equal

$$\frac{\sqrt{r}}{L+R+r}$$

and the current generated by the derived field-magnet circuit dynamo would equal

$$\frac{\sqrt{r_1}}{r+\frac{L\,R}{L+R_1}}$$

of which

$$\left(\frac{\sqrt{r_1}}{r_1+\frac{L\,R_1}{L+R_1}}\right)\frac{L}{L+R_1}=\frac{\sqrt{r_1}}{\frac{R_1 r_1}{L}+R_1+r_1}$$

flows in the field-magnet circuit, and

$$\frac{\sqrt{r_1}}{L+\frac{L\,r_1}{R_1}+r_1}=\frac{\sqrt{r_1}\,\frac{R_1}{L}}{\frac{R_1 r_1}{L}+R_1+r_1}$$

flows in the exterior circuit; but in order that the magnetic field of both dynamos may be equal, the product of the current strength and the length of the wire of each dynamo must be equal.

$$\text{Therefore}\quad \frac{\sqrt{r}}{L+R+r}\sqrt{R}=\frac{\sqrt{r_1}}{\frac{R_1 r_1}{L}+R_1+r_1}\sqrt{R_1} \qquad (1)$$

and when the energy expended in the exterior circuit is the same with both dynamos.

$$\left(\frac{\sqrt{r}}{L+R+r}\right)^2 L=\left(\frac{\sqrt{r_1}\,\frac{R_1}{L}}{\frac{R_1 r_1}{L}+R_1+r_1}\right)^2 L \qquad (2)$$

By dividing the square of equation (1) by equation (2) we get

$$\frac{R}{L}=\frac{L}{R_1}\quad\text{therefore}\quad R_1=\frac{L^2}{R} \qquad (3)$$

Therefore, when the strength of the magnetic field and the work performed in the exterior circuit is the same with both dynamos, R_1 always equals

$$\frac{L^2}{R}$$

When the total energy expended in the circuit is the same with both

$$\left(\frac{\sqrt{r}}{L+R+r}\right)^2(L+R+r)=\left(\frac{\sqrt{r_1}}{r_1+\frac{LR_1}{L+R_1}}\right)^2\times$$
$$\times\left(r_1+\frac{LR_1}{L+R_1}\right)$$

By filling in the value of R_1 in (3) this equation becomes

$$\frac{r}{L+R+r}=\frac{r_1}{r_1+\frac{L^2}{L+R_1}}$$

$$\text{therefore}\quad \frac{r}{L+R+r}=\frac{1}{1+\frac{L^2}{r_1(L+R_1)}}$$

$$\text{therefore}\quad \frac{L+R+r}{r}-1=\frac{L^2}{L+R}\cdot\frac{1}{r_1}$$

$$\text{therefore}\quad r_1=r\left(\frac{L}{L+R}\right)^2 \qquad (4)$$

When therefore

$$R_1=\frac{L^2}{R}\text{ and }r_1=r\left(\frac{L}{L+R}\right)^2$$

the magnetic field, the energy absorbed by the exterior circuit, and the total energy expended in the circuits are the same in both dynamos, so that they are equally economical.

When the thickness of the insulating material of the different wires used in the dynamo is a constant fraction of the diameter of the conductor, then the sectional areas of the wires on the armatures and field-magnets varies as the square root of the reciprocal of its resistance.

Let a and a_1 equal the sectional area of the conductors of direct and derived circuits armatures. Then

$$a=\sqrt{\frac{1}{r}}\text{ and }a_1=\sqrt{\frac{1}{r_1}}=\sqrt{\frac{1}{r\,\frac{L^2}{(R+L)^2}}}$$

$$=\sqrt{\frac{1}{r}}\,\frac{L+R}{L}\quad\text{therefore}\quad a_1=a\,\frac{L+R}{L}$$

and the diameter of the conductor of derived circuit armature would equal

$$\sqrt{\frac{L+R}{L}}$$

that of the conductor on direct circuits armature.

Also if f and f_1 equal the sectional areas of the conductor on direct and derived circuit field-magnets, then

$$f = \sqrt{\frac{1}{R}} \text{ and } f_1 = \sqrt{\frac{1}{R_1}} = \sqrt{\frac{1}{\frac{L_2}{R}}}$$

$$= \sqrt{\frac{1}{R}}\,\frac{R}{L} \text{ therefore } f_1 = f\,\frac{R}{L}.$$

In some dynamos a portion of the field-magnet coil is in the line circuit and another portion in the derived circuit. By observing certain rules in the winding of the armature and field-magnet, this method is equally economical. If a portion of the wire on the field-magnet of a direct circuit dynamo were replaced by finer wire in a derived circuit, then the resistance of the wire retained in the line circuit would equal

$$\frac{R}{n} = R_{11}$$

and the resistance, of R_1 and r_1, with which the remaining portion of field-magnet and the armature would have to be rewound, would be found by the following formulæ :—

The current generated in the circuit would

$$= \frac{\sqrt{r_1}}{r_1 + \frac{R_1(L+R_{11})}{R_1+(L+R_{11})}} = \frac{\sqrt{r_1}\,(R_1+(L+R_{11}))}{r_1 R_1 + r_1(L+R_{11}) + R_1(L+R_{11})}$$

and when the energy expended in the armatures, line circuit, and field-magnets is the same in both dynamos, then

$$\left(\frac{\sqrt{r}}{L+R+r}\right)^2 r \qquad (1)$$

$$= \left(\frac{\sqrt{r_1}\,(R_1+(L+R_{11}))}{r_1 R_1 + r_1(L+R_{11}) + R_1(L+R_{11})}\right)^2 r_1$$

$$\left(\frac{\sqrt{r}}{L+R+r}\right)^2 L \qquad (2)$$

$$= \left(\frac{\sqrt{r_1}\,R_1}{r_1 R_1 + r_1(L+R_{11}) + R_1(L+R_{11})}\right)^2 L$$

$$\left(\frac{\sqrt{r}}{L+R+r}\right)^2 R \qquad (3)$$

$$= \left(\frac{\sqrt{r_1}}{r_1 R_1 + r_1(L+R_{11}) + R_1(L+R_{11})}\right)^2 \times$$

$$\times\,(R_1^2 R_{11} + R_1(L+R_{11})^2)$$

by dividing equation (1) by equation (2)—

$$r_1 = r\,\frac{R_1^2}{(R_1+(L+R_{11}))^2} \qquad (4)$$

and by dividing equation (3) by equation (2)—

$$R = R_{11} + \frac{(L+R_{11})^2}{R_1} \text{ therefore } R_1 = \frac{(L+R_{11})^2}{R-R_{11}}$$

by filling in this value of R_1 in equation (4) and making

$$R_{11} = \frac{R}{n},$$

the following values of r_1 and R_1 are obtained.

$$r_1 = r\left(\frac{L+\frac{R}{n}}{L+R}\right)^2 \text{ and } R_1 = \frac{\left(L+\frac{R}{n}\right)^2}{R\,\frac{n-1}{n}}$$

and the sectional areas, a and a_1, of the wires of armatures in the direct and derived circuit dynamos would be—

$$c = \sqrt{\frac{1}{r}}, \text{ and } a_1 = \sqrt{\frac{1}{r_1}} = \sqrt{\frac{1}{r\left(\frac{L+\frac{R}{n}}{L+R}\right)^2}}$$

$$= \sqrt{\frac{1}{r}}\,\frac{L+R}{L+\frac{R}{n}} \text{ therefore } a_1 = a\,\frac{L+R}{L+\frac{R}{n}}$$

or if d and d_1 equal the diameters of r and r_1, then

$$d_1 = d\sqrt{\frac{L+R}{L+\frac{R}{n}}}$$

Since a portion only of the conductor of the field-magnet is placed in the derived circuit, the sectional area of that portion, "R," would vary directly as the square root of the quantity and inversely as the square root of the resistance, then the sectional areas, "f" and "f_1," of the field-magnet in direct and derived circuit would be

$$f = \sqrt{\frac{1}{R}} \text{ and } f_1 = \sqrt{\frac{\frac{n-1}{n}}{R_1}} = \sqrt{\frac{\frac{n-1}{n}}{\left(L+\frac{R}{n}\right)^2}}$$

$$= \sqrt{\frac{1}{R}\left(\frac{R\,\frac{n-1}{n}}{L+\frac{R}{n}}\right)^2} \text{ therefore } f_1 = f\,\frac{R\,\frac{n-1}{n}}{L+\frac{R}{n}}$$

and since the current flowing through R and R_1 is as

$$1 \text{ to } \frac{R\,\frac{n-1}{n}}{L+\frac{R}{n}}$$

the currents flowing in the field-magnet circuits are proportional to the sectional areas of the circuits, and the energy expended in the field-magnets is therefore equal. The sectional area of the conductor of the armature would also be increased "in the derived circuit dynamo" directly as the increase of current flowing in the circuit.

W. MOON.

To Enterprising Electricians and Others.—We read in an American contemporary, with a name similar to that of our own journal, but with which we have no desire to be confounded, the following curious paragraph : "We are rather surprised that no enterprising electrician turns his attention to the construction of *electric steam* launches." We would suggest an electric-steam-gas engine as another good opportunity for enterprise.

Electric Light Disclosures.—Unpleasant disclosures in the electric light world continue, to the surprise, we fear (says the *Citizen*), of many a disgusted shareholder. The latest addition to the list of unsuccessful concerns in this line of business is the "Duplex" Electric Light, Power, and Storage Company. True, the report and accounts are not yet before us, but a lithographed circular, just issued by the directors, ill conceals their indecent haste to secure further funds to meet pressing engagements. The enforced calmness attempted throughout this document is amusingly relieved by the evident trepidation under which the staff of the "Duplex" Company are labouring. A few quotations will explain : "The present position of the company is perfectly satisfactory from a technical and industrial point of view." "The only serious difficulty now existing is the want of available working capital." "It is necessary for the debentures to be immediately subscribed in order that outstanding accounts for materials may be settled. If this be done, the board see their way to carrying on the business in a satisfactory manner." What on earth is the position of a company in a "technical and industrial" point of view? We fear it signifies anything outside the commercial point of view, which is unfortunately the only direction in which a shareholder cares to direct his eyes.

ESTIMATES FOR ELECTRIC LIGHTING.

WE have been favoured with a copy of an approximate estimate by the Electric Carbon, Storage, and Apparatus Manufacturing Company of Scotland, to the Vestry of St. Mary, Newington, for an installation of electric lamps, the particulars of which are as follows. We also give the Vestry's estimate for the same work, and it will be seen that the estimated cost of the installation is double, and the cost of maintenance considerably higher than that shown in the company's figures.

COMPANY'S

Estimate for an Installation of 6,000 incandescent lamps of 16 candle-power, 50 incandescent lamps of 50 candle-power, making a total candle-power of 98,500, for which would be required 500 effective horse-power.

Compound steam-engines with boilers, complete ...	£3,600	0	0
Fixing ditto	200	0	0
Self-regulating safety dynamo machines, complete ...	3,000	0	0
Fixing ditto	50	0	0
Shafting and belting	150	0	0
Engine-house	500	0	0
Altering present street lamps to suit electric light ...	100	0	0
Main and branch leads, as shown on plan, with allowance for future extension to St. George's Church, with Dr. Higgs' patent earth-plate ...	2,000	0	0
Contingencies	500	0	0
	£10,140	0	0

Cost of Maintenance (Annual).

1,690 tons of coal, at 20s.	1,690	0	0
1 manager	180	0	0
1 assistant	104	0	0
2 engine drivers, at 30s.	156	0	0
2 ,, stokers, at 20s.	104	0	0
2 boys, at 5s.	26	0	0
Oil, waste, water, &c.	300	0	0
	£2,560	0	0

Revenue.

From 5,000 lamps, at gas rate	£3,662	0	0
,, depôt gas account	160	0	0
,, public streets	205	0	0
Profit on sale of lamps, at 6d. each, say 6,000 ...	150	0	0
	£4,177	0	0
Annual revenue	£4,177	0	0
,, expenditure	2,560	0	0
Balance to carry forward to redemption of debt*	£1,617	0	0

VESTRY'S

Estimate for the Installation.

Four 150 H. P. engines, including boilers, setting, and connections, at £9 per H. P.	£5,400	0	0
For building shaft, &c.	1,000	0	0
Four dynamo machines, equal to 1,500 lights each, at 15s. per light	4,500	0	0
Fixing bands, connections, and sundries	1,200	0	0
Cables, main electric lines and testing boxes, &c., from the depôt to the extreme limits of the compulsory district, provision being made to lay down a sufficient line to extend the supply to St. George's Church, when required	6,000	0	0
Exchange of lamp-posts, columns, and lanterns throughout the compulsory district, providing for new lamps and fittings for same	500	0	0
Lamps, columns, and necessary fittings for street lighting between the depôt and the railway bridge, including necessary lamps and fittings for providing and supplying of electricity to the Vestry Hall and depôt	500	0	0
Contingencies	900	0	0
	£20,000	0	0

Maintenance Charges.

1,690 tons of coal, at 20s...	£1,690	0	0
One electrician	250	0	0
One assistant (outside) at	104	0	0
Two engine-drivers at 50s. per week	260	0	0
Two stokers at 30s. each per week	234	0	0
One assistant in engineer's room	52	0	0
Oil, waste, water, bands, &c.	550	0	0
	£3,140	0	0
Annual revenue	£4,027	0	0
Annual expenditure	3,140	0	0
Balance to carry forward in payment of interest, &c.	£887	0	0

* The interest and instalment for the first year on a loan of £15,000, taken at 3½ per cent., would be £1,525.

The estimate of the company includes a letter from Mr. J. E. Jackson, the Secretary, to the Vestry Clerk, which is worth reproducing if only to show the disinterestedness of the writer. It will be observed that Mr. Jackson does not consider Dr. Siemens and Mr. St. George Lane-Fox as altogether unworthy of attention in matters of this kind, and he evidently feels quite confident in Dr. Higgs and his dynamo. At the end Mr. Jackson cannot restrain a feeling which is natural to those who can foresee the brilliant future of the electric light, and he accordingly waxes eloquent, not to say poetical. He will, we feel sure, excuse the few remarks we have made on his communication to the Vestry, remarks which were brought forth by the ingenuous manner in which he has written, the whole epistle being couched in an open, frank, candid, and unreserved style which is most refreshing to meet with in the electric light world.

Leith, *May 16th*, 1883.

DEAR SIR,—In handing you this estimate I am not actuated by primary motives of personal profit, but more to enable you to convince your ratepayers and the Vestry of the enormous advantages they would derive from the adoption of a good system of electric lighting. I have read with pleasure your report and the remarks therein of Dr. Siemens and Mr. Lane-Fox, both of whom are authorities of considerable experience, and their remarks deserve due attention. I must, however, take exception to the statement by Mr. Lane-Fox, "that with good machinery a combustion of 1¼ lbs. of coal will yield 1 horse-power per hour." In practice, and with the best machinery, 2 lbs. to 2¼ lbs. of good Cardiff coal is required to yield 1 horse-power per hour. This I have proved by long experience with the best class compound engines. Also with an economical dynamo, such as the one invented by Dr. Higgs, 200 candle-power may safely be calculated per indicated horse-power.

The figures of Dr. Siemens, as regards the comparative cost of electricity as against gas, are convincing to an ordinary observer; and the only thing that remains is to instil confidence into the minds of the public, and you will have their hearty support in your endeavours in the direction in which I am glad to see you are moving.

You will see from the estimate which I have the honour to submit to you that the initial cost of the whole plant is ... £10,140 0 0
The annual expenditure 2,560 0 0
The annual income 4,177 0 0

Leaving a balance of ... ... £1,617 0 0 clear profit, which will enable you to pay off your loan in less than 15 years with ease.

Moreover, the profits are likely to exceed the estimated amount, for while the expenditure will remain almost stationary, the revenue from lighting will increase until within three or four years the whole 6,000 lamps will be called for, thus adding £1,000 per annum to the revenue.

Profit may also be derived from rent of meters, sales of fittings, and also from the use of electricity as motive-power for driving sewing-machines and other light work.

Another important factor is the accumulator, without which you should not attempt house lighting, for it is not reasonable to expect your customer to consume what he pays for immediately he gets it; but he should be able to store the electricity for use when required, and also be able to use it for other purposes than lighting.

You will see that I have estimated for the use of an earth-plate for the return current; but if you prefer to have return wires, the cost would be £1,500 more.

The figures quoted, although approximate, are yet as nearly exact as it is possible to get; being rather over than under what an actual estimate would be: but should your vestry favour me with instructions for another estimate when you are prepared to go to work, I shall be most happy to go fully into the matter and quote you exact figures.

In reference to the system of lighting which is likely to prove most economical, I would point out that Dr. Higgs' dynamo is the *only* self-regulating one, and is the one which will be generally used so soon as its merits become known, as it is apparent to the most dull of comprehension that no system can be so economical, which is not self-regulating.

I am in position to say that my company can offer you terms and facilities such as no other company has yet entertained, and at the same time give a full guarantee relieving you of all risk of failure.

I have pleasure in enclosing you a copy of the report made by a deputation from the Bootle Town Council, knowing that it will be of interest to you, as being testimony from an independent and unbiassed source.

I have confidence in thinking that these figures will convince the most determined opponent of the new illuminary, that from a purely commercial point of view, it will repay the outlay with interest, and even if this were not the case, and the electric light proved to be light for light, more expensive than gas. Yet there are other considerations to take into account; is it nothing to be free from the danger of explosion and fire? nothing to be free from the overbearing heat and poisonous fumes, and the constant flicker of gas? nothing to have the atmosphere of our homes once more pure and free from the smokiness of gas? I think these advantages far outweigh any question of £ s. d., but when these advantages are coupled with economy, surely it can be only madness that would refuse to discard the conservatism that would poison our bodies and burn our homes rather than advance into the soft, soothing, and economical light of electricity.

To L. J. Dunham, Esq., Walworth.

(Signed) JOHN EVANS JACKSON.

Yours truly,

THE APPLICATION OF ELECTRICITY TO MOTIVE POWER.

By G. BINSWANGER.*

THERE is no element in nature that is so readily adapted to the transmission of power, and certainly no element, in producing power, can be so easily controlled as electricity.

Ranging from the tiny movement of the diaphragm of the telephone, which I may describe as a millionth of a foot-pound, to existing machines developing many horse-power, it is evident that a great future is in store for the application of electricity to motive power, since the work may be performed at a considerable distance from the place where it is generated, and we can by means of this subtle agent make use of a considerable proportion of that energy with which nature provides us so lavishly, but which runs to waste at present. That a current of electricity is able to produce motion and exert force is a well known fact, and there are at present many electro-motors, all designed for the purpose of converting the largest percentage of electrical energy into useful work, but with different degrees of success.

There seems to be a tardiness in recognising the utility of electro-motors, this is probably because there are now many motors—steam, gas, and water—all of known and estimated efficiency; while in the early days of steam there existed *no* motor for it to replace, but a great want of such, hence the fact that it rapidly rose to the present state of perfection and became an object of universal utility.

As the first ideas of a steam-engine originated from the alternate lifting and falling of the lid of a tea-kettle, under the pressure of the expanding gas within, so the capability of an electro-magnet to lift, release, or repel a piece of iron, suggested the application of this motion for the purpose of moving machinery. So several motors were devised, some having a movable electro-magnet attached to a beam, which, being alternately attracted and repelled by another fixed electro-magnet, gave motion to the beam, and so to a crank and fly-wheel.

No electro-motor constructed upon this principle can utilise much of the electrical energy put into it; the law of magnetic attraction teaches us that the force of a magnet is decreased proportionately to the square of the distance from it, therefore it is clear that the distance of the travel of such a magnet must be small to be effective at all. So to obtain a fair amount of crank stroke the end of the beam must be considerably elongated beyond its pivot. This arrangement, while increasing the *space* of the motion, decreases its power at the point of application, viz., the crank.

Steam being an expansive gas and maintaining a practically constant pressure upon the piston of a steam-engine to the end of each stroke, such a crank and fly-wheel is a good method of transforming the rectilinear motion of the piston into the corresponding rotary motion of the crank shaft and so driving machinery.

It was necessary that electricians should recognise the great difference between the magnetic effect of a current of electricity and the expansive effect of a volume of steam, and to construct their motors not after the style of steam-engines, but suitable to the peculiar behaviour of the alternating magnetic attraction, so as to obtain the greatest efficiency. Froment made a decisive step in this direction when he devised his rotary electro-motor. Here the disadvantage of the unequal lever is dispensed with, and the magnetic attraction applied directly to the bars of iron placed round the periphery of the wheel.

Here again a serious drawback exists, in the space between the magnetic pole and the bar to be attracted, leaving too much work to be accomplished by the momentum of the wheel. Jacobi subsequently improved this by winding insulated wire upon the iron armatures, alternately making and breaking contact of the current round them, keeping his fixed electro-magnets constantly magnetised and arranging them so that there was not much work depending upon the momentum of the wheel.

This might be said to have placed the electro-motor in the light of a machine that could be really used for practical purposes.

But although the motor of Jacobi was tolerably efficient, he found a great disadvantage attending its use in the expense of maintenance, for the consumption of zinc and acid in his batteries was far in excess of the corresponding production of power.

A really good electro-motor may turn 75 per cent. of the original energy into useful work, whereas a good steam-engine utilises only 15 per cent. of the energy of the coal.

But the energy of zinc is only one-fifth that of coal, and even counting the increased efficiency of the electric over the steam-engine, the former would cost thirty times more in maintenance, acids and all allowed.

When dynamo and magneto-electric generators began to attain perfection this obstacle was partly removed, and the electro-motor began to be improved again. The present types of electro-motors are, broadly speaking, reversed dynamos, that is, having a current from another source sent through its field and armature causing the latter to revolve.

I have two motors here, one driving that lathe, and the other a ventilating fan, 36 inches in diameter. Both these are the invention of Mr. Reckenzaun, a gentleman who has devoted considerable time and attention to the application of electricity as a motive power, and it is due to his kindness that I have these motors to show you to-night. Side by side with others these develop a higher efficiency than has yet been attained, and are, as you see, compact and constructed so as to combine cheapness with durability.

The electro-motor is especially well adapted for locomotive purposes, because its construction is simple, its parts are few, and therefore not easily disarranged. It also occupies a smaller space than other motors for its power, except indeed those which are driven by the expansion of a gas which is stored under enormous pressure, which obviously is extremely dangerous. Therefore it bids fair, under certain conditions, to be a formidable rival to steam in the propulsion of railway trains, tramcars, and other vehicles, but perhaps in no way to confer such a benefit upon commerce as when applied to what I shall term auto-locomotion. This simply means sending single cars or a train, laden with letters, newspapers or goods, upon its way without personal attendance, the whole apparatus being controlled at either end or different stations along the line. A tremendous speed of, say, 300 miles per hour, could thus be attained without the risk appertaining to our present system at 60 miles. I simply wish to show that electricity is the only agent by which we shall attain such a transport; of course the limit to speed would depend upon circumstances that are not allowed for in this rough calculation, such as air resistance, heated bearings, and friction of machinery, but with suitable shape of vehicle and size of motor, such a speed is not so mythical as it may seem.

So our parcels and goods could fly, as it were, with almost incredible speed, from town to town. This is a fair probability, and one which the proposed "parcels' post" may soon render a practical possibility. No other agent than electricity could be employed for this purpose, its ready transmission along a conductor and its peculiar behaviour in a motor, seem to be specially suited to such a want.

An electro-motor when running induces a current *back* through wires in the opposite direction, tending to oppose the current which is producing the motion. This, called the "back current" or "counter electromotive force," is greatest at a certain high speed.

The efficiency of the motor depends upon the proportion of the speed, load, and driving current, and is greatest when the driving current *utilised* equals the back current, or, to speak more correctly, when the driving current is reduced to half its strength by the resistance of the back current, *plus* the resistance of the coils of the motor.

However, great speed is necessary in order that we should obtain efficiency, and economise the expenditure of energy. Every electrical engineer will agree with me that in this subject of auto-locomotion electricity has unique advantages. As a light it is rivalled by gas, as a motor by steam; in these two applications its intrinsic merits are somewhat overshadowed by the competition of these older established agents and vested rights, and it is obvious that the vast plant and machinery using gas and steam are not to be done away with at short notice.

In auto-locomotion no such rival exists; the great advantage of speed, which I have mentioned, combined with easy control over each vehicle, economy in the cost of rolling-stock, and in the space of the permanent way, will, I maintain, render electricity applied in this way cheaper and better than our present method of transmission, both in first cost and maintenance. I will leave it to another occasion to go into details, but there are no difficulties of construction that cannot be surmounted, and, considering that by means of auto-locomotion we could send our parcels to Glasgow in two hours, the matter is certainly worthy the attention of some of our men of progress.

Electro-motors, again, may come into universal use for the propulsion of small vessels, this being done at present by means of small engines that are very costly to maintain compared with the cost of large engines working on shore, or those on board large ships. The difference being from 2 lbs. to 4 lbs. of coal per hour in the large condensing engines and 8 lbs. to 12 lbs. per hour in the small non-condensing ones; so the energy of a large and cheap-working engine employed to replace a small expensive one must be a gain. Electricity supplies this method of transmission by the use of secondary batteries. I have here 30 cells of the Faure-Sellon-Volckmar type of accumulator, kindly lent me by the Electric Power Storage Company, and, though small, they are supplying us with light and power for the space of this lecture, a considerable residue remaining unused. Conductors being out of the question, what could be better than such cells for conveying the energy of the shore engine to the motor on board of the launch or tug-boat? Some think that the weight of these accumulators is a serious objection to their use; but, power for power, an electro-motor with its cells does not weigh so much as a steam-engine, boiler, and coals to last for the same time.

Who has attempted to enjoy himself by running down the Severn or up the Thames in a steam launch and fairly succeeded? The smoke, dirt, the greasy attendant, and the stertorous snorting of the exhaust steam, all detract from the pleasure of the trip. How much nicer is it to glide along in a launch electrically propelled, no noise but the murmur of the motor, like a bee buzzing o'er a flower; no dirt nor smoke; and, what is more important, plenty of room. Unlike a boiler, the accumulators may be stowed away under seats, anywhere in fact, out of the way; the motor and machinery may be under the deck and hid from view, yet thoroughly under control.

Railways and tramways electrically propelled permit of the employment of two systems—the transmission of power from a central station by means of a conductor; or taking accumulators on the vehicles themselves. The advantages of either system depend upon the circumstances of each individual case.

Accumulators may some day replace the boiler, tender, and coal of the present steam locomotive. For the wheels of a locomotive to exert the necessary adhesive force upon the rails, which is low in this country—being from 400 lbs. to 450 lbs. per ton—the engine must have weight, which must be so that the adhesive power exceeds the tractive force or the wheels will slip. The average weight of a steam locomotive (not including the tender) is from 20 to 35 tons, incline engines from 40 to 47 tons. This may give some idea of the fact that the weight of accumulators does not militate against their employment in locomotion so much as might be imagined.

* Lecture delivered at Balloon Society, Royal Aquarium, Westminster, Friday, June 1st, 1883.

Railway companies would not be inclined to alter their whole permanent way and dispense with all their steam locomotives at once, for an ordinary steam-engine could not travel upon the rails occupied by an electrical engine, if the power were transmitted by conductors, without seriously interfering with the action of the latter.

But an old steam locomotive could be replaced by an electro locomotive using accumulators, without in any way obstructing the other rolling stock; and this, probably, is the only way in which electricity is ever likely to be applied to existing lines of railway. In fact, for the electrical propulsion of all vehicles the accumulator seems to be the best method of transporting the electrical energy wherever we desire to take it.

I will now deal with the application of electro-motors to stationary purposes. This can advantageously be done in all cases where "high speed" is desirable. Where machinery is driven by a steam-engine, such a speed is attained at present by means of bands, pulleys and gearing, while in most instances the electro-motor could be directly applied, avoiding the great loss by slip and friction as well as the expense of the present system.

Another great advantage of electro-motors is that small manufacturers, requiring from ¼ to 1 horse-power, could apply the power in their own houses, saving the rent of expensive premises with steam-power. The only difficulty connected with this application of electrical power is the electricity itself. I propose to supply small accumulators and establish charging stations at different parts of the town, where these small consumers of power could have them recharged at a trifling cost.

I look forward to see, shortly, advertisements or signboards intimating that Messrs. So-and-So, power or energy merchants, are prepared to supply their merchandise, viz., electrical power, at so much per horse-power-hour.

Suppose that the loss of power in the use of such accumulators be 50 per cent., including the loss in the charging dynamo, then from a suitable charging-station the energy could be supplied far cheaper than steam-power to small consumers, and this expense could include the cost of cartage.

Electro-motors are also eminently adapted for ventilating purposes, a matter which is now rather prominently before the public in the shape of that vexed question, "How to ventilate the tunnels of the District Railway." I will not be so arbitrary as to assert that electricity is the best method of attaining this desirable object, but it certainly possesses properties which render it suitable for this purpose, with less expenditure of money and space, than any other system known at present, without interfering with the street traffic.

You see that a fan 3 ft. in diameter can be driven at a rapid rate, producing a powerful current of air by means of a comparatively small motor, and this smaller one, attached to a flexible wire, can be sent round the room in motion, so that every one may see how it can be accomplished.

Now applying some such method, as instanced by this larger fan, to the series of tunnels in the Underground Railways, I find, from a very rough calculation which I have made, that, by means of a series of appropriately sized and distributed fans for exhausting foul air—driven by motors actuated by electricity conveyed by conductors from generators at suitable stations along the line—it would require something like 60 H. P. to thoroughly ventilate the whole railway; this, including attendance, maintenance, and depreciation, would cost little more than £3 per day—a trifling amount per passenger, a small decimal of a penny—not worthy of a moment's consideration in comparison with the increase of comfort and almost entire elimination of the unhealthiness of the transit which would ensue. To give you some idea of the benefit thus accruing I may in a few words tell you that roughly speaking it is safe to assume that 200 trains pass through per day, taking about five minutes to pass from station to station including stoppages; that each engine consumes about 6 lbs. of fuel in each of these five minutes, in all 1,200 lbs. of fuel in each section requiring—

$$1{,}200 \times 150 = 180{,}000 \text{ c. ft. of air for combustion.}$$

The products of this combustion are, for every 100 parts of coal consumed, say,

60 parts Nitrogen.
25 ,, Carbonic oxide.
12 ,, ,, acid.
3 ,, other gases,

none of which are suitable to the support of animal life and even, though we may be compelled to inhale it during a short time only, cannot be otherwise than injurious to health as well as productive of discomfort. On a calm day there is little or no natural ventilation in these tunnels; for whatever fresh air may be caused to circulate by the passing trains is in great part consumed by the locomotives leaving, as our throats and noses convince us, far from sufficient for the full requirements of the passengers; and this need of a thorough and economical system of ventilation must perforce continue until the engines themselves also are driven by electricity and the tunnels cease to be factories for the production of poisonous and noxious gases.

In large mills, again, where there are one or two large compound condensing steam-engines, and a number of small non-condensing engines scattered about to save the somewhat awkward arrangement of shafts and gearing which would be necessary to transmit the power of the large engine all over the mill, electro-motors would be a cheaper and more efficient method of obtaining local power than such small wasteful engines.

Large engines are more economical in management than smaller ones, for many reasons; for example, the indicated horse-power of a piston 10 in. in diameter, with a speed of 400 ft. per minute, is ·952 horse-power per pound of steam pressure per square inch, and if the piston be 20 in. in diameter, the horse-power of one pound pressure per square inch of area is 3·807, showing at once that a large engine is more efficient. And such large engines are usually fitted with condensers, removing the pressure of the atmosphere from the exhaust side of the piston, which in non-condensing engines affords a resistance often amounting to 16 lbs. per square inch, so that at 60 lbs. of steam there is only 44 lbs. effective pressure. This makes a difference in the consumption of coal, the larger and more economical engine consuming from 2·5 to 3 lbs. of coal per horse-power hour, and the smaller non-condensing engine from 8 to 10 lbs. per horse-power-hour.

A large condensing engine in a mill could be made to drive the whole of the machinery for suitable installation of a dynamo and motors, and, no doubt, paper makers and cotton manufacturers will not be slow to find out the advantage of this system.

Eight horse-power, consuming 3 lbs. of coal per horse-power per hour, or 24 lbs. per hour, costing about 4d. on the large engine, could be made to transmit, say, 7 H. P. to do the work of a non-condensing engine, which consumes 56 lbs. of coal per hour at a cost of 6d. These figures are merely approximate, but may serve to indicate a decided economy in this application of electricity.

If, however, the original energy be derived from the great stores of nature, such as watercourses, and transmitted to any place where it may be required, by means of electricity the acme of cheap power is attained, no matter what may be the loss in transmission. Because watercourses seldom existed where they were most required, that cheap source of energy has been allowed to lie dormant for centuries, but it need be so no longer, for nearly every country in the world has enormous power running to waste that could be utilised to furnish both light and motive-power in every town. I do not propose to go into intricate calculations upon this subject, nor do I wish you to follow me in imagination to such a remote region as the Falls of Niagara, where tens of thousands of horse-power thunder down every day of our lives, and, commercially speaking, run to waste, but I will cite a single instance, nearer home—but a few miles from this place—where a small river rises in a beautiful valley near Sevenoaks; it affords a simple illustration that has a thousand counterparts in the United Kingdom, each of which would far exceed it in effect. This small stream runs through the grounds of several mills, and within a few hundred yards of many more, and as far as the owners of these mills are able to do, they avail themselves of the water-power. 180 horse-power is thus used, another thousand could be obtained from this little stream, so great is its fall and quantity. Yet thousands of pounds per annum are spent by these mill-owners in supplementing the water-power by steam; belts, gearing, &c., are too costly in maintenance as a means of transmitting power, therefore the water is wasted because the place where power is required is a short distance away from it. There is not much loss in electrical transmission where short distances like these are concerned, and considering these facts we cannot but acknowledge that the world is too far advanced to allow such power to run to waste much longer.

I have endeavoured, in dealing with this subject, not to allow enthusiasm to carry me beyond the boundaries of practicability.

The extension of the uses of electricity in the future is a matter entailing much labour, thought and expenditure, and its accomplishment must be the work of good honest engineers and electricians.

Some, styling themselves electricians, I am sorry to say, would try and convince the public that by means of electricity they can attain perpetual motion, or other equally absurd chimera; but I am more sorry to think that there are people credulous enough to believe them. The events of the past two or three years have made us acquainted with the disastrous consequences of such folly.

No electrician of any standing lent himself to such scandalous schemes, and the electrical press, without exception, repeatedly warned the public; none regretted the interference of speculators on their domain more than electricians, and the harm that it has done to the prospects of electrical lighting is enormous indeed. Soon electromotive force will be foremost and attract the attention of the world. Let us hope that its progress will be marked by honest work, and that step by step it will attain, without hindrance or prejudice, that success that is inherent in it, and that it will supply the progressive wants of the ever-increasing population of the world and conduce to the happiness of mankind.

NOTES.

Electric Lighting.—The Admiralty has evidently decided on giving the incandescent light a fair trial on board our troopships. H.M.S. *Himalaya*, which was lighted by the Swan United Electric Light Company (Limited) about six months ago, has now set out on her second voyage with the electric light. The officers on board were able to send in to the Admiralty a most favourable report when she returned from China after a voyage of nearly four months. At a low estimate the lamps were in use quite 1,000 hours, and out of a total of over 240 lamps only 25 were broken. These figures will, therefore, speak for themselves. We may add that after her four months' trip no repairs or overhauling were necessary, although a careful inspection was made of every detail. An interesting experiment was made just before this ship sailed on May 26th. The Admiralty is considering the question of supplementing the interior lighting with deck lamps hung in the rigging for dis-

embarking troops, &c., and it was determined to try a group of incandescent lamps in preference to one arc lamp. For this purpose two regulation ship's lanterns were fitted with eight 50 C. P. Swan lamps each. The result obtained exceeded all expectation, and the general decision was that, owing to the equal distribution of the incandescent system it was a more thoroughly practical light to work by, and we understand that it is highly probable that a similar system will be adopted in future cases.

At the Commissioners of Sewers meeting on Tuesday, Mr. Deputy Pepler brought up a report from the Streets Committee, submitting a report from the engineer relative to the Edison system of electric lighting on the Holborn Viaduct, and recommending that the same be printed and circulated for the information of the Commissioners, which was agreed to.

At a meeting of the Aberdeen Town Council on Monday, Lord Provost Esslemont made a statement regarding the Electric Lighting Provisional Order applied for by the city. The provisions insisted upon by the Board of Trade were such, he thought, as to make the speculation anything but remunerative to the community; and he moved that, unless the Corporation were empowered to charge the cost of the manufacture of the light, including charges for interest, and unless those desiring the supply became bound to take it for three years, the order should be withdrawn. Bailie Duffus moved that no further action be taken, and that the order be dropped. On a division, the Lord Provost's motion was carried by a large majority.

The Dundee Committee met last week, when Provost Moncure explained that the Brush Company order for the lighting of the streets of the town had been satisfactorily adjusted. Among other things the company agreed to appropriate no less than £20,000 of capital for providing a station in Dundee forthwith, and to deposit £3,000 in security for the performance of the obligation.

A contemporary says the electric light towers in Union and Madison Squares, New York, are 250 ft. high, 3 ft. in diameter at the base, and 8 in. in diameter at the top. They are constructed in tubular sections of steel plate, each 50 in. long, riveted end to end. About 100 ft. of the top is first completed, and is then placed in a perpendicular position, and raised to a sufficient height to admit of a section being placed underneath, when the two are riveted together, and the tower raised another stage to receive the next section. The mast is prevented from swaying by six wrought-iron guys, and is embedded in a strong foundation 20 ft. in diameter and 12 ft. in depth, resting upon a cast-iron base plate. The lamps are suspended near the top from a movable frame, and under a copper reflector, which serves as a protection to them. Underneath the reflector is the device for raising or lowering the carriages to which the lamps are attached. It traverses two iron guides on each side of the mast, and these are also constructed to form ladders by which the lamps may be reached in case of the disarrangement of the apparatus. A short distance above the ground is a balcony on which the operator stands in trimming the lamps. The use of these towers appears to be rapidly extending in America.

That electric lighting is not everywhere done for nothing is evident from the prices charged in Oregon and other places in the United States. For the sum of 5 dollars per lamp per week, if in use all night, or 3.50 dollars if used up to 10 o'clock on six nights a week, the Brush Company is prepared to give light.

On Tuesday, Messrs. John Key & Sons, Kinghorn, Fife, launched from their shipbuilding yard a large screw steamer for the Melbourne, Sydney, and Newcastle passenger and cargo trades. The vessel was named the *Gado*, and is to be lighted throughout by incandescent lamps.

Mr. Brockelbank, the secretary of the Brush Electric Light and Power Company of Scotland, writes to us regarding two notices as to work of this company in Scotland. 1st. In Aberdeen the company is, as stated by the *Aberdeen Journal*, lighting their case-room, Mr. Duncan's shop, and some of the stalls in the new market, with incandescence lamps fed from secondary batteries; and we are asked to say that the lamps are of the newest type of Lane-Fox (57 volts), and that the machine is one of the Brush 25-light incandescence. Great satisfaction is expressed respecting them. 2nd. The inquiry held in Edinburgh was intended to obtain a verdict from the people of that city as to whether the electric light was wished for, and there was no hint or notice of any kind given by the Board of Trade to this company or the company's agents that a full inquiry would be held. It was therefore a complete surprise to the board of the company when they learned that the Bill had been or was to be reported against, because no evidence was sent to Edinburgh as to the financial position of the company, &c. All this was argued before the Board of Trade on the 11th and 15th of May, and was therefore unnecessary in Scotland. Evidence can still be produced on this point, and as to the want being felt in Edinburgh, the witnesses that were called and the signatures the agents in that city produced in the company's favour showed beyond doubt that the want was felt. This being the first local inquiry, says Mr. Brockelbank, it was very clearly the duty of the Board of Trade department to let the agents know what evidence was required. Had this been done, Major Marindin would have had conclusive evidence placed before him.

Messrs. Shippey Brothers inform us that the Universal Electric Light Company has started works at No. 34, Charles Street, Hatton Garden, for the exclusive manufacture of a new incandescent glow lamp, the special feature in connection with which is the preparation of "peat moss" used for the carbon filament. It is claimed by the inventor of this lamp that a far more brilliant light is obtained with less power, the average life of the lamp exceeds 2,000 hours, and they are made from 20 to 500 candle-power. The works are lighted with the new lamps, and can be inspected by cards to view, to be obtained from Messrs. Shippey Brothers, 13 and 14, King Street, Cheapside, who have obtained the sole agency for the sale of this lamp. We are *surprised* that this lamp should have been in existence so long and yet be so little known. Taking 5 hours per day for testing its duration, it must have taken 400 days to ascertain its average lifetime. It may be, however, that the inventor has been engaged day and night in testing his lamp, in which case our figures of course require modification. A lifetime of 2,000 hours for an incandescent lamp at 500 candle-power is an exceedingly good result, and one of which any inventor may well be proud. We shall hope to give *our own* impressions of this lamp shortly.

On Tuesday evening, May 29th, the Chevalier E. Rosenbusch, C.E., on behalf of the Eastern Electric Light and Power Company (Limited), gave an exhibit of incandescent light for domestic use at his residence in Strada Mercanti, Malta. The exhibit went off with great success. The lights displayed consisted of side lights, chandeliers, and table lamps of varigated colours, and gave every satisfaction to those present, who heartily congratulated Chev. Rosenbusch and Mr. William Robinson, the electrical engineer, who lucidly explained to the company the process of the lighting.

The Camberwell Vestry met on Wednesday of last week, when the clerk reported the receipt of a letter from Messrs. Walter Webb & Co., solicitors to the Metropolitan (Brush) Electric Light and Power Company (Limited), stating that as the company had been unsuccessful in arranging terms with the vestry, they had determined for the present session not to proceed further with the provisional order, and that the Board of Trade had been so informed.

Messrs. Shepherd & Beveridge, floorcloth manufacturers, 151, Queen Victoria Street, E.C., have arranged with the National Electric Company of Glasgow for the lighting up of their drying and printing rooms in Kirkcaldy, with Edison's incandescence lamps. No less than 1,440 lights are to be used.

The Newington Vestry held a special meeting on Wednesday evening of last week to consider a motion by Mr. Robinson, rescinding a resolution previously passed by the vestry in favour of the electric light. After a long discussion the motion was rejected by 33 to 27.

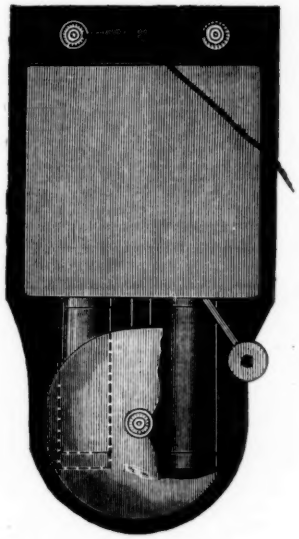
Baron Rothschild has had his carriage illuminated by means of the electric light. Accumulators were placed under the coachman's seat, and the usual lamps had the electric lights placed inside them. The electricity supplied was sufficient to give light for a hundred hours.

The United States Electric Illuminating Company made the first experimental test of the electric light installation on Brooklyn Bridge, on the 19th ult. The seventy lights used were divided into two distinct circuits of 35 lights, the light giving intensity of each lamp being 2,000 candles (nominal). Two separate engines are used, one for each circuit. The total length of the leading wires is said to be 30,000 feet.

The s.s. *Clan MacArthur*, which has been built for Messrs. Cayzer, Irvine, & Co.'s Clan Line, by Messrs. Scott & Co., of Greenock, started from the Clyde on Saturday, the 2nd inst., for a preliminary cruise, with a large party on board. The vessel has been lit throughout with incandescent lamps by the Glasgow branch of the Edison Electric Light Company. We understand that the owners are so pleased with the complete success of the lighting that they have placed the lighting of another steamer, the *Clan MacIntosh*, with the Edison company, without inviting tenders from other firms.

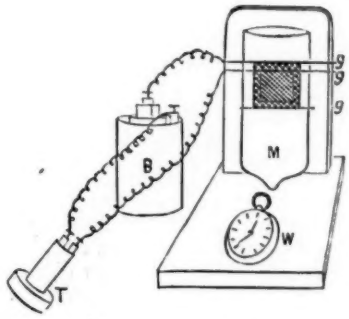
For some time past the committee of the Gloucester County Lunatic Asylum have been considering the advisability of adopting the electric light and have at last settled to light up a portion of their new buildings. They have intrusted the carrying out of the work to Messrs. Woodhouse & Rawson, of 11, Queen Victoria Street, London. This, we are informed is the first time the electric light has been adopted in lunatic asylums, the lighting of which has to be *very carefully* considered. Dowson's patent gas, Crossley's gas-engines, Faure-Sellon-Volckmar secondary batteries and Woodhouse and Rawson incandescent lamps are to be used.

Electric Bell and Battery Combination.—We are always pleased to notice electrical apparatus when it characterises progress in public utility; such is the new bell and battery combined, which is introduced by the General Electric Apparatus Company, of 29, Aldermanbury. This presents the appearance of an ordinary 3″ bell, but will ring by simply connecting the terminals. The batteries are a pair of Clarke's patent chloride of silver cells, 2½ in. long by ⅞ in. diameter, and these are let into the base-plate under the gong, as shown in the illustration; this allows of their easy removal if necessary. These cells have two brass caps, forming the positive and negative terminals; they are coupled



in series, contact being made by a small spring. The whole apparatus is neat and compact, and commends itself to the public; while for travellers and invalids it is invaluable, all that is required being to connect the two wires from an ordinary push to the bell terminals, and we believe that the cost is very moderate. We understand that the electromotive force of the cells is 1·3 volts each, and their internal resistance arranged according to the resistance of the bell electro-magnets and outer circuit, so as to waste no battery power. This being the case, and these patent cells having, it is said, no local action whatever, and not consuming any material when not in circuit, they last for a very long time; if used for ordinary bell work they will continue in action for from 12 to 18 months.

A Vacuum Microphone.—The apparatus which we illustrate was devised by Mr. J. Munro, and exhibited at a recent meeting of the Society of Telegraph Engineers. It consists of a glass bulb, M, exhausted by a mercury pump to a high vacuum, such as exists in an incandescence lamp. Three platinum electrodes, g g and g^1, are sealed through and through the bulb. The first pair of wires, g g, carry



a plate of stretched iron gauze between them, and the other electrode, g^1, carries a movable piece hinged round it, and free to rest lightly against the fixed plate behind. These two pieces of gauze are connected in circuit with a battery, B, and a telephone, T. A watch, W, is placed on the base-board, and its ticking is distinctly and loudly heard in the telephone, the sound being peculiarly clear and ringing. The instrument is very sensitive when well adjusted by bringing the poles of an external magnet in front of the movable gauze, g^1, outside the bulb.

The Brush Accumulator.—The works of the Brush Electric Company, Cleveland, O., according to American reports, are now turning out lead electrodes for the Brush accumulator at the rate of 7,700 lbs. a day.

Legal.—Mr. Lane-Fox's Patent for the Employment of Secondary Batteries in Electric Lighting.—This important patent, which is dated 9th October, 1878, came before the Solicitor-General on Friday, 1st June, upon an application made by Mr. Lane-Fox to disclaim from his patent all the claims originally made by him, except that which covers the employment of secondary batteries in combination with parallel arc distribution, as described in his specification. His application was opposed by the Swan United Electric Light Company, Messrs. R. E. Crompton and Co., and the British Electric Light Company, upon various grounds, among which were that the invention to which Mr. Lane-Fox wished to limit his patent by the proposed disclaimer was wanting in novelty, that it was not the proper subject for a patent, that it was not sufficiently described in his provisional specification, and that the proposed disclaimer would alter the character of the patent.

Mr. Webster, Q.C., and Mr. Moulton (instructed by Messrs. Grover and Humphreys, solicitors, and Mr. J. C. Mewburn, patent agent), appeared for Mr. Lane-Fox in support of the disclaimer; Mr. Aston, Q.C., and Mr. Chadwyck Healey (instructed by Mr. J. H. Johnson, solicitor) appeared for the Swan United Company; Mr. Ashton, Q.C., and Mr. Phipson Beale (instructed by Messrs. Brooks and Son, patent agents) for Messrs. R. E. Crompton & Co., and Mr. E. Carpmael (instructed by Messrs. Wilson, Bristows, & Carpmael, solicitors) for the British Electric Light Company.

Evidence in support of the disclaimer was given by Mr. Lane-Fox, the patentee, Prof. Fleeming Jenkin, F.R.S., Prof. Silvanus Thompson, D.Sc., and Mr. R. Sabine, C.E.; and in support of the several oppositions by Mr. J. W. Swan, Mr. R. E. Crompton, Dr. Hopkinson, F.R.S., Mr. W. H. Preece, F.R.S., Prof. Ayrton, F.R.S., Prof. Oliver Lodge, Mr. D. G. Fitzgerald, and Hon. R. Brougham.

After a long hearing the Solicitor-General decided to grant Mr. Lane-Fox's application for leave to disclaim. The claim under the patent will, therefore, be for the employment as described in the specification of secondary batteries as reservoirs of electricity in combination with a mode or system of distribution such as is therein explained.

Personal.—We learn that Mr. Bennett Pell, who has recently resigned the appointment of General Manager to the Eastern Extension Telegraph Company, has become associated with the firm of Messrs. Johnson & Phillips, telegraph engineers and electricians. We congratulate Messrs. Johnson & Phillips in having secured the co-operation of a gentleman of such considerable administrative skill and wide telegraphic experience.

Obituary.—We much regret having to record the death of Sir James Carmichael, Bart., which occurred at 6 o'clock on Thursday morning, after a few weeks' illness. Sir James, as is known to most of our readers, was the chairman of the most successful telegraph company of the day, namely, The Submarine Telegraph Company; he was also president of the Mediterranean Extension Telegraph Company, and vice-president of the Electric "Sun" Lamp and Power Company. His loss will be regretted by all who were brought in communication with him, and especially by ourselves, to whom his kindness and his dignified but genial manner will form a most lasting remembrance.

The Case of M. Philippart.—A telegram, dated Brussels, June 6th, states that M. Philippart was provisionally set free on that day, he giving bail to the amount of 15,000f.

NEW COMPANIES REGISTERED.

South Kensington Mutual Electric Lighting and Supply Company (Limited).—Capital £230,000, in £5 shares. Objects: To supply electricity for lighting purposes in South Kensington and elsewhere. Signatories (with one share each): *Sir Charles T. Bright, 20, Bolton Gardens; *J. Collinson, 90, Cromwell Road; *C. M. McHardy, 1, Grenville Place; B. de C. Nixon, 15, Grenville Place; W. L. Cole, 5, Stamford Road; Vice-Admiral W. G. Jones, 26, Ashburn Place; J. W. Johns, 16, Grenville Place; Sir Stuart Hogg, 14, Southwell Gardens; W. Tyrrell, 95, Cromwell Road; Colonel H. Lumsden, 13, Southwell Gardens; *Sir Julius Vogel, 135, Cromwell Road; A. Cooper, 80, Gloucester Road; G. F. Chester, 18, Emperor's Gate; Lieut.-Col. R. Armstrong, 6, Ashburn Place; Captain W. de W. Abney, 3, St. Albans' Road; A. H. Robinson, 5, Bolton Gardens; R. Romer, 5, Grenville Place; W. S. Gilbert, 24, The Boltons; R. C. Want, 31, Earl's Court Square; Lady Maria Spearman, 3, Grenville Place; T. L. Read, 11, Petersham Terrace: J. E. Boehm, 78, Cornwall Gardens; Sir C. J. Freake, Bart., 1, Cromwell Houses; the Baroness A. A. M. de Pallandt, 4, Emperor's Gate; J. Edge, 110, Cromwell Road; the Hon. Sir Saul Samuel, 15, Courtfield Gardens; J. Collett, 12, Fopstone Road; *J. Muirhead, 23, Regency Street (electrical engineer), and Captain J. O. Hopkins, R.N., 50, Stanhope Gardens. The signatories whose names are preceded by an asterisk are directors. Directing qualification, 50 ordinary shares; remuneration, £500 per annum. Registered 30th ult., by Burchells & Co., 5, The Sanctuary, Westminster.

Society of Telegraph Engineers and Electricians. Objects: To acquire the property, rights, and obligations of the existing society (established in 1871), and to promote the general advancement of electrical and telegraphic science and its application. Every member undertakes to contribute to the assets, in the event of winding up, such sum, not exceeding £1, as may be required. As the property and income of the society will be devoted solely to the furtherance of its objects, and not for division as dividend or profit, the Board of Trade has granted a licence, in pursuance of Section 23 of the Companies Act, 1877, authorising the omission of the word limited from the title. Signatories: Willoughby Smith, 18, Wharf Road, City Road; Latimer Clark, 6, Westminster Chambers; W. Grylls Adams, 43, Notting Hill Square; H. G. Erichsen, 119, Bishopsgate Street Within; D. E. Hughes, care of London Joint Stock Bank, 69, Pall Mall; W. H. Preece, Wimbledon; C. E. Spagnoletti, Great Western Railway, Paddington; C. Graves, General Post Office. Registered 31st ult. Wilson, Bristowes, & Carpmael, 1, Copthall Buildings.

LATEST QUOTATIONS.

Authorised Issue.	Share.	Name.	Paid	Closing Quotations, June 6.	Business Done.
		ELECTRIC LIGHT.			
40,000	10	Anglo-American Brush Co.	7	3⅞ - 4¼	3⅞
		Do. Do.	10	6⅛ - 7⅛	
30,000	5	Australasian Electric Light, Power & Storage Co.	3	⅜ - ½	
24,900	10	British Insulite Co., Limited, "A" Shares	5	1⅝ - 2⅛	
30,000	5	Brush Electric Light & Power Co. (Scotland)	2½	⅛ - ¼	
25,000	5	Great Western Electric Light & Power Co.	2½	⅛ - ¼	
24,980	5	Hammond Electric Light & Power Supply Co.	2½	2½ - 3	
40,000	5	Indian & Oriental Electrical Storage Works Co.	2	.. - ..	
172,500	1	Maxim-Weston Electric Light and Power Co.	1	¼ - ⅜	
..	..	Metropolitan Brush Electric Light & Power Co.	3	.. - ..	
40,000	5	Pilsen-Joel & General Electric Light Co.	2	¼ - ⅜	
..	..	South African Brush Electric Light & Power Co.	2½	.. - ..	
100,000	5	Swan United Electric Light Co., Limited	2½	1⅛ - 1⅜	
		TELEGRAPHS.			
2,116,400*l.*	Stk.	Anglo-American, Limited	100	50 - 51	50½
2,441,800*l.*	Stk.	Do. Preferred (Def'd. receiving no div. until	100	82 - 83	82
2,441,800*l.*	Stk.	Do. Deferred 6 p. c. has been paid to Pref.)	100	20 - 21	
130,000	10	Brazilian Submarine, Limited	10	11⅛ - 12	11⅞
16,000	10	Cuba, Limited	10	10 - 10½	
6,000	10	Do. 10 per cent. Preference	10	17 - 18	17½
13,000	10	Direct Spanish, Limited	9	5½ - 6	5¼
6,000	10	Do. 10 per cent. Preference	10	15½ - 16½	
65,000	20	Direct United States Cable, Limited, 1877	20	12⅛ - 12⅝	
100,000*l.*	100	Do. 6 per cent. Debenture, repayable 1884	100	99 -102	
380,000	10	Eastern, Limited	10	10⅛ - 10⅝	
70,000	10	Do. 6 per cent. Preference	10	13 - 13½	
232,000*l.*	100	Do. 6 do. Debentures, repayable Oct. 1883	100	100 -102	
200,000*l.*	100	Do. 5 do. do. Aug. 1887	100	101 -104	
200,000*l.*	100	Do. 5 do do. Aug. 1899	100	104 -107	
199,750	10	Eastern Extension, Australasia & China, Limited	10	12 - 12⅛	12 3/16.12.¼ ¼
50,250		Do. New Shares. 1883	8	8⅛ - 9	
320,000	100	Do. 6 p. c. Debentures, repayable Feb. 1891	100	108 -110	
500,000	100	Do. 5 p. c. (Australian Gov. Subsidy) Deb. 1900	100	104 -107	105½
140,000	100	Do. do. registered, repayable 1900	100	104 -107	
100,000*l.*	100	Do. 5 per cent. Debenture, 1890	100	101 -104	
254,300*l.*	100	Eastern and South African Limited 5 per cent. Mort. Deb. Registered redeemable 1 Jan. 1900	100	103 -106	
345,700*l.*	100	Do. do. do. To Bearer	100	103 -106	
22,050	10	German Union Telegraph and Trust Limited	10	9⅛ - 10⅛	
163,390	10	Globe Telegraph and Trust, Limited	10	7 - 7⅛	7⅛ - 7/16
163,209	10	Do. 6 per cent. Preference	10	12⅞ - 13⅛	13.12⅞
125,000	10	Great Northern	10	12⅞ - 13	
100,000*l.*	100	Do. 5 per cent. Debentures	100	101 -104	
300,000	100	Do. 5 per cent. Debentures	100	101 -104	
31,200	10	India-Rubber, Gutta-Percha and Telegraph Works	10	29½ - 30½	30
100,000	100	Do. 6 per cent Debentures, 1886	100	103 -106	
17,000	25	Indo-European, Limited	25	31½ - 32½	
38,148	10	London Platino-Brazilian, Limited	10	3⅞ - 4¼	
12,000	10	Mediterranean Extension, Limited	10	1½ - 2	
8,200	10	Do. 8 per cent. Preference	10	6 - 7	
9,000	8	Reuter's, Limited	8	9½ - 10	
280,000	Stk.	Submarine	100	247 -252	
58,225	1	Do. Scrip	1	2⅛ - 2⅜	
4,200	Cert.	Submarine Cables Trust	100	106 -110	
37,350	12	Telegraph Construction and Maintenance	12	33½ - 34½	
150,000	100	Do. 6 per cent. Bonds, 1884	100	101 -103	
186,750	5	Do. 2nd Bonus Trust Cert.	2½	1⅜ - 1⅝	
30,000	10	West Coast of America, Limited	10	4½ - 5	
150,000	100	Do. 8 per cent. Debentures	100	107 -109	
69,910	20	Western and Brazilian, Limited	15	6¼ - 6⅝	
200,000*l.*	100	Do. 6 per cent. Debentures "A" 1910	100	108 -110	
2,500	100	Do. 6 p.c. Mort. Deb. series B of '80. red. Feb., 1910	100	100 -103	
1,500	$1,000	Western Union of U. S. 7 p.c.1 Mort.(Building)Bds.	$1,000	122 -124	
1,030,000*l.*	100	Do. 6 per cent. Sterling Bonds	100	103 -106	
88,321	10	West India and Panama, Limited	10	1⅛ - 1⅜	1
34,563	10	Do. 6 per cent. 1st Preference	10	6½ - 7	6⅞
4,669	10	Do. 6 do. 2nd do.	10	5 - 5½	
		TELEPHONES.			
154,165	1	Con. Telephone & Maintenance, Ld. Nos. to 154,165	1	⅜ - ½	½
200,000	1	Oriental Telephone Co., Nos. 80,001 to 300,000	¼	⅜ - ½	
100,000	5	United Telephone Co.	5	9½ - 10	9¾.9¾

The West Coast of America Telegraph Company.—This company intimates the restoration of telegraphic communication, *vid* Galveston, with Valparaiso, Mollendo, Arica, Iquique, Antofagasta, Santiago de Chili, Buenos Ayres, and all telegraph stations in Peru, Chili, and the Argentine Republic.

The Brazilian Submarine Telegraph Company.—The directors have declared an interim dividend of 3s. per share, or 6 per cent. per annum, free of income-tax, for the quarter ended the 31st of March last, and payable on the 25th inst.

TRAFFIC RECEIPTS.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ended May 18th amounted to £2,892.

The Cuba Submarine Telegraph Company, Limited. The number of messages passing over the lines of this company during the month of May was 3 848, estimated to produce £3.300, against 3.408 messages, producing £3.544, in the corresponding month of last year. The February receipts, estimated at £3,900, realised £4 036.

The Direct Spanish Telegraph Company, Limited. The estimated receipts for the month of May were £1,638, against £1,038 in the corresponding period of last year.

The Eastern Extension (Australasia, &c.) Telegraph Company, Limited. The receipts for the month of May amounted to £32,156, and £33,087 in the corresponding period of 1882.

The Great Northern Telegraph Company. The receipts for May amounted to £22,600. The aggregate from January 1st to May 31st amounted to £99,520, compared with £94,150 in 1882, and £93,172 in 1881.

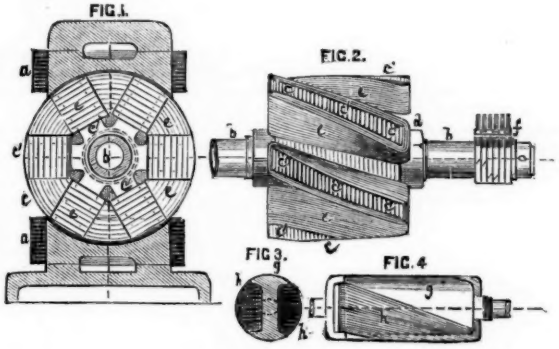
The West India and Panama Telegraph Company, Limited. The estimated receipts for the half month ended May 15th were £3,404, as compared with £3,240 in the corresponding period of 1882. The January receipts, estimated at £4,669, realised £4,684. The estimated receipts for the half month ended May 31st were £3,028, as compared with £3,261 in the corresponding period of 1882.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ended May 18th were £1,941, and for the week ended May 25th, £1,931, each after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1882.

4691. "Generation and distribution of electric energy." F. C. PHILLIPS. Dated October 2. 6d. Has for object to cause electric generating apparatus to automatically adjust itself to the conditions of the circuit, and either keep a constant current flowing therein, or maintain a constant difference of electromotive force between the two ends of the external circuit independently of the varying resistances or conditions of the said circuit. For this purpose the inventor arranges the exciting circuit of the field-magnets of the generator or generators in such wise that the combined effects of the exciting current or currents, and of the current in the armature will produce a sensibly constant magnetic field; that is to say, he causes the magnetising effect of the current which flows round the magnet coils to increase at the same rate as the opposing or demagnetising effect of the current in the armature coils, and *vice versâ*; thus the magnetising current will attain its maximum when the armature is developing the full amount of current for which it is designed, and will attain its minimum when an infinite or approximately infinite resistance is inserted in the circuit fed by the armature coils. This minimum magnetising effect of the exciting current is that which is required to produce the required electromotive force in the armature coils when there is no opposing or demagnetising current in those coils.

4694. "Machinery for generating and utilising electricity." E. EDWARDS, A. F. ST. GEORGE, and H. L. PHILLIPS. Dated October 3. 6d. This invention relates more especially to machinery or apparatus used for the purpose of generating a current or currents of electricity to be used for obtaining light, motive-power, or for other purposes. It has for its objects new and improved methods of constructing and arranging the parts of the apparatus, so that it is very simple and easily and cheaply made, and so that the current or currents of electricity generated by it are very uniform and constant in character, a moderate amount of power only being required. Fig. 1 is a



transverse section of the machine, and fig. 2 is a separate view of the revolving helical armature, which is shown, having three pairs of projecting helically shaped arms or ribs. *a*, *a*, is the field-magnet, which may be of any suitable form and construction, *b* is a hollow central axis carried in suitable bearings, and having fixed upon it the armature, *c*, consisting of a large number of thin soft iron plates, c^1, c^1, precisely similar, and each having six radial arms. Each succeeding plate, c^1, has a slight angular advance in its position up the shaft or axis, *b*, as compared with the preceding one, so that the whole series, when adjusted and tightened by the nut, *d*, form radial helical ribs or teeth of any desired pitch, and at equal distances apart. Round the helically arranged arms are wound coils of insulated wire, *e*, of length and thickness proportioned to the purpose to which the apparatus is to be applied, and the ends of these coils are brought to a collecting and commutating or regulating device, *f*, of any of the ordinary well-known kinds. Instead of forming each arm of a large number of separate plates as described, it may be formed of solid metal made or curved to the proper helical shape, as illustrated in figures 3 and 4, in which is shown a soft iron armature, *g*, having two opposite parallel recesses in which the insulated wire coil or coils, *h* is wound; the whole armature and coil are shown in fig. 4 twisted helically, in the same manner and for the same purpose as in the arrangements first described, but the armature is shown of solid metal instead of being built up of separate thin plates. As a modification of the arrangements described, the revolving armature may be made with its arms parallel with its axis instead of helical, the poles of the field-magnet being made helical. Or the arms of the revolving armature and the poles of the field-magnet may both be made more or less helical.

4695. "Electric lamps." E. EDWARDS and A. F. ST. GEORGE. Dated October 3. 6d. Relates to that form of electric lamps, or apparatus for producing light by means of electricity, which is known as an "arc" light, in which the light is produced by the passage of a current of electricity between the extremities of carbon rods. In such electric lamps it is necessary that the extremities of the carbon rods described should be retained constantly at as nearly as possible the same distance apart, in order that the light may be steady, uniform, and as free as possible from flickering and variation; and the present invention has for its object improved methods of constructing and arranging apparatus by which such distance may be automatically preserved constant as the length of carbon decreases.

4696. "Electrical accumulators or secondary batteries." A. F. ST. GEORGE. Dated October 3. 2d. The invention has for its objects novel methods of constructing and operating such accumulators or secondary batteries, so that they are lighter, more compact, and more easily transported from place to place when desired, and are at the same time more effective than such apparatus as heretofore ordinarily constructed and used. (*Provisional only.*)

4712. "Electric bells and alarm clocks, &c." B. W. WEBB and H. P. F. JENSEN and J. JENSEN. Dated October 3. 6d. Relates to electric bells and alarm clocks and apparatus to be used in connection therewith, and the said invention comprises various improvements and novel features hereinafter described. According to one part of the said invention, the inventors combine with a clock of suitable construction an electric battery and bell, and apparatus whereby the said clock can be set (in a similar manner to an ordinary alarm clock), so that it will complete the circuit at a given time and cause the bell to be sounded.

4717. "Disc dynamo and magneto-electric machines." J. GORDON and J. GRAY. Dated October 4. 6d. Two discs rotate on parallel axes, with their peripheries pressed in contact by springs, or otherwise, so that the one may drive the other after the manner of friction wheels. These discs consist of thin sheets of brass, copper, or any other good conductor of electricity; this thin web of the disc is surrounded by a ring or flange to form a broad surface of contact when the two discs are pressed together. The discs are divided by radial cuts running from the circumference to within a few inches of the centre, into a considerable number of sections. A magnet is placed over the discs, so that its pole-pieces shall cover two sections at least of each disc lying about the line of centres. The magnet may be an electro or permanent magnet; but an electro-magnet is preferable. The current in the rotating discs or armature passes from the axis of one disc, through the point of contact of the two discs to the other disc. The magnet coils are connected up in shunt circuit to the bearings. The main external circuit is also connected to the bearings.

4718. "Electric railways, &c." J. HOPKINSON. Dated October 4. 6d. Has for its principal object to provide means in connection with electric railways whereby leakage of the electric current is prevented or greatly diminished. According to the said invention the inventor divides the rail (either one or both of a pair) into sections or lengths insulated from each other. He carries the conductor along the track preferably completely insulating the said conductor, and he leads from it branches to each section or length of rail. In each of these branches he provides a switch by which communication with the conductor is maintained whilst sufficient current flows by an electro-magnet through the coils of which the current passes.

4735. "Secondary batteries." C. T. KINGZETT. Dated October 5. 4d. Relates to secondary batteries or so called magazines of electricity and has reference to novel means for effecting the storage of energy developed by the agency of primary batteries or dynamo machines or otherwise. Instead of employing dilute sulphuric acid as the electrolyte as is generally done, the inventor employs solutions of salts of the earths or alkalies, such for example as the sulphate of sodium, and by this proceeding he is enabled to use, partially or entirely, the metal iron in the construction of the electrodes or terminal plates or supports or retainers or frames upon, against or in which the active material or materials employed is or are deposited placed or fixed.

4740. "Call apparatus for telephone lines." M. BENSON. (Communicated from abroad by J. P. Stabler of North America.) Dated October 5. 1s. In those systems of telephone service where there is a "Central Office" or "Exchange" from which service wires radiate to the several subscribers' stations, there are necessarily attendants or "operators" at said central office, whose duties are to answer the signals made by persons at said stations, and to place any two of them so desiring in communication. In order to accomplish this it is necessary that the operator shall be able to send as well as receive signals. The signal to the exchange is usually the dropping of an annunciator; that to the subscriber is the sounding of a bell. One service wire may extend to a single subscriber's station or to a number of such stations. In the latter case there are two systems or modes of calling the subscriber with whom it is desired to communicate. The first and most generally employed is that wherein each local station bell on that line is caused to sound the number designating the subscriber's station with which communication is desired. The other system is designated the "individual call," because no bell is sounded except at the station which it is desired to call. The invention relates to the latter system. In all instruments heretofore devised for individual calls, wherein the mechanism of each local station instrument is brought into position by successive electrical impulses, these impulses are controlled by a manual key; that is to say, the circuit is closed for each impulse by a key actuated by the hand of the operator. It is evident that in this method the manual dexterity of the operator is the limitation as to speed, and that it is also liable to inaccuracies in accordance with the operator's personal equation of error. The invention substitutes an automatic electrical pole changer to control the currents which move the mechanism into position, and thus greatly facilitates the operation and eliminates the personal equation of error, and substitutes an automatic stop for the manual stop depending upon the observation of the operator to limit the movement of the mechanism.

4752. "Intensifying fluorescent or phosphorescent electric lighting, &c." R. KENNEDY. Dated October 6. 6d. This invention provides means of intensifying and increasing the lights produced by discharging high tension charges of electricity in vacuo between two or more metal or carbon or other conducting or partially conducting bodies; these bodies may be pointed wires or balls or flat discs, and sometimes both, partly or altogether coated with various fluorescent substances, or with phosphorescent substances such as sulphuret of barium or sulphuret of calcium. An important feature of this invention is the use or application of the oxides of the alkaline metals for

intensifying the light produced by the discharge of high tension or negative electricity in vacuo. For this purpose the inventor uses such oxides as alumina or magnesia in the form of extremely thin strips, plates, or tissues; and he obtains such strips, plates, or tissues in the necessary condition either in the ash of burnt paper in the manufacture of which alumina or clay is used, or the oxides may be pressed or rolled into pieces of the necessary thinness or lightness.

4756. "Secondary voltaic batteries." A. KHOTINSKY. Dated October 6. 2d. In preparing the elements of secondary voltaic batteries it is usual to employ one of the lower oxides of lead such as red lead, and then to subject the elements to long-continued electrolytic action, whereby this substance is converted into a higher oxide, the peroxide. According to this invention, the inventor, in the first place, prepares chemically the peroxide of lead, thus avoiding loss of time and expenditure of electrical energy; and he employs the peroxide so produced to form part of the battery elements, the battery being thus at once ready to receive a charge of electricity. The chemical process which he employs to produce the peroxide is to treat red lead with dilute nitric acid, or to subject hydrated oxide of lead such as white lead to the action of chlorine. The peroxide of lead produced in either of these ways is made up with subdivided lead in any known form; for example, it may be used in combination with plates of spongy or fibrous lead, or with network of lead, or with a mass of lead wires, pellets or granules.

4764. "Electrical apparatus for the propulsion of boats." A. RECKENZAUN. Dated October 6. 2d. Relates to the utilisation of electric energy for the propulsion of boats, and comprises the employment of electric motors, generators, and secondary batteries or accumulators. *(Void by reason of the patentee having neglected to file a specification in pursuance of the conditions of the letters patent.)*

4768. "Covering wire for electrical purposes." J. J. C. SMITH. Dated October 7. 6d. Consists essentially in taking rubber composition or other vulcanisable compound or any other suitable waterproof insulating compound in its plastic state, laying it in a thin film or sheet on a woven or other sufficiently strong fabric, pressing them together by calendering or otherwise, so as to incorporate the rubber with the cloth, then cutting the so-prepared sheet in a long strip of sufficient width to reach around the wire longitudinally, leaving a surplus for a joining flange drawing this tightly around the wire and bringing the faces of the compound together with the pressure so that the rubber is inseparably united around the wire. The projecting flange or edge of rubber and fibrous material thus produced, is then cut off so as to leave the wire covered with a thin jointless film or covering of rubber composition surrounded by a fibrous envelope, after which the covering is vulcanised on the wire by the requisite degree of heat applied in any usual or suitable manner, but preferably through the medium of a water bath and under heavy pressure, or packing in powdered soap stone.

4771. "Production of electric light, &c." O. G. PRITCHARD. Dated October 7. 6d. Relates to an improvement in the production of the electric light whereby great steadiness is insured, the feeding of the carbon being rendered absolutely imperceptible. The invention consists in causing the carbons to be brought into contact and separated to form the arc at such rapidly recurring intervals that by virtue of the persistence of vision, the intermittent character of the light due to the arc shall not be perceptible to the eye. This end is attained by imparting to the one carbon an exceedingly rapid reciprocating motion of uniform extent in the direction of the other carbon, which is meanwhile steadily fed up to the point of contact, the carbon which receives this reciprocating or percussive action virtually forming an abutment for the other carbon to press against, constantly as it were, so that the carbon will be continually fed up as fast as it is consumed, and the relation of the one carbon to the other will therefore be to all practical intents and purposes maintained absolutely constant.

4777. "Mechanism for electrical communication on railways." R. TATHAM. Dated October 7. 6d. Relates to improvements in mechanism or apparatus by means of which electrical communication may be established between one portion of a railway train and another portion thereof, or between separate railway trains when travelling in the same or in opposite directions, or between a train and a railway station or stations or a telegraph office or station or *vice versâ*. For the above object the inventor places between or in proximity to the rails upon which the train or trains travel an additional rail or rails formed of suitable material supported in such manner as to be electrically insulated. The aforesaid insulated rail or rails communicate electrically with any ordinary telephonic or telegraphic apparatus for receiving and transmitting intelligence, which apparatus is placed in the guard's van or other part of the train by means of a wheel or wheels or other equivalent having a grooved angular or other form of periphery to correspond with the contour of the above-named insulated rail or rails, such wheel or wheels or other equivalent having a grooved angular or other form of periphery, to correspond with the contour of the above named insulated rail or rails, such wheel or wheels or other equivalent being carried by levers acted upon by springs or weights so as to be kept in contact with the insulated rail or rails aforesaid, or instead of the before-named wheel or wheels it is proposed in some cases to make use of plates or springs of metal mounted or held so as to be capable of sliding in contact with the insulated rail or rails before named, so as to make electrical contact therewith.

4780. "Electric lamps." S. F. WALKER and F. G. OLLIVER. Dated October 7. 6d. Relates to electric or voltaic arc lamps, and is designed to provide the same with improved feed mechanism to be applied to one or both of the carbons or electrodes to determine or regulate their approximation to each other, and thereby prevent variations or fluctuations of the light. For this purpose the inventors combine with one or both of the electrodes a clutch, which is arranged, controlled, and operated in such a manner that the electrode to which it is applied will be thereby held or drawn back, or permitted to approach the other electrode in proportion to the rate of combustion of the electrodes.

4809. "Secondary batteries." R. TATHAM and A. HOLLINGS. Dated October 10. 4d. Consists essentially in constructing the positive and negative elements of the battery with increased acting surface, in comparison with the weight and in employing a mixture or combination of vegetable fibre and metal for that purpose. Under the first part. Paper-making pulp, prepared from unsized paper, cotton or linen rags, or any other vegetable fibre, is mixed when moist with 80 to 90 per cent. of peroxide of lead for the positive plate of the battery, or with 80 to 90 per cent. of sub-oxide of lead for the negative plate, the whole is left to settle down, after which a thin lead plate is coated on each side with this mixture to a depth of from one-eighth to a quarter of an inch, the whole is then placed in a mould and submitted to a heavy pressure, it is afterwards dried at a gentle heat and the edges carefully varnished. The plates are now ready to set up in pairs, and will be found to polarise very quickly. Under the second part. Plates are prepared by mixing the vegetable pulp above-mentioned with lead in a fine state of division, obtained by mixing red lead to a paste with boiled linseed oil, and submitting the whole to the action of dilute sulphuric acid. Under the third part. Oxide of lead is partly reduced by chemical means and employed in combination with the vegetable pulp as the negative element.

PROCEEDINGS OF SOCIETIES.

The Society of Telegraph Engineers and of Electricians.

(Continued from page 464.)

MAXWELL describes an experiment of Beetz, in which an exceedingly small filament of iron was deposited by electrotype, under the influence of a strong magnetic field, in order to arrive at the inherent polarity of comparatively few molecules, and, as its magnetic force was very great, he regards the experiment as conclusive. My own experiments show that we have far less external magnetic force from a solid bar than from a thin tube or flat bar of the same surface exposed to a limited exciting cause. We know that magnetism does not penetrate to a very great depth, and we also know that, if to a thin steel permanent magnet we place another piece unmagnetised, or, better still, a rod of soft iron, its external polarity is greatly reduced; consequently the external evidence of polarity is not a direct measure of the degree of rotation, nor of the total inherent polarity of its mass. We may have a great superficial *external* rotation superposed upon rotations of an opposite nature, as will be seen later; and thus the internal molecules of a magnet often act more or less as an external armature in closing its circle of attractions.

I have stated my belief that the molecule itself possesses its inherent polarity, which, like gravity, is an endowed quality for which we have no more reason to suspect the cause to be elementary electric currents than that elementary currents should be the cause of gravity, chemical affinity, or cohesion and its polar power of crystallisation, most of which are affected by an electric current. We have a certain analogy between electric currents and magnetism, but not so great as the analogy between the magnetic polarity of a molecule and its other endowed qualities.

Magnetism, like chemical affinity, cohesion, and crystallisation, has its critical points. Faraday discovered that at red-yellow heat iron instantly lost its apparent polar magnetic power, to be as instantly restored at red heat, the critical point varying in iron, steel, &c., and being the lowest in nickel. This would be difficult to explain upon Ampère's theory, as we should have to admit the instant destruction or cessation of the elementary currents, to be again restored at a few degrees less temperature. It would be equally difficult to explain under my view, if it did not belong to a whole class of phenomena due to the possession by the molecules of various endowed qualities, of which chemistry and all our means of research can only teach us their critical points, without attempting to explain why, for instance, iron has a greater affinity for oxygen than gold. We know that it is so; we know that the molecules of all matter are endowed with certain qualities having certain critical points, and I can see no reason for separating their magnetic inherent polarity from their numerous other qualities.

Neutrality.

The apparatus needed for researches upon evident external polarity requires no very great skill or thought, but simply an apparatus to measure correctly the force of the evident repulsion or attraction; in the case of neutrality, however, the external polarity disappears, and we consequently require special apparatus, together with the utmost care and reflection in its use.

From numerous researches previously made by means of the induction balance, the results of which I have already published, I felt convinced that in investigating the cause of magnetism and neutrality I should have in it the aid of the most powerful instrument of research ever brought to bear upon the molecular construction of iron, as indeed of all metals. It neglects all forces which do not produce a change in the molecular structure, and enables us to penetrate at once to the interior of a magnet or piece of iron, observing only its peculiar structure and the change which takes place during magnetisation or apparent neutrality.

The induction balance is affected by three distinct arrangements of molecular structure in iron and steel, by means of which we have apparent external neutrality.

Fig. 1 shows several polar directions of the molecules as indicated by the arrows. Poisson assumed, as a necessity of his theory, that a molecule is spherical, but Dr. Joule's experimental proof of the elongation of iron by $\frac{1}{71000}$ of its length when magnetised, proves

at least that its form is not spherical; and as I am unable at present to demonstrate my own views as to its exact form, I have simply indicated its polar direction by arrows—the dotted oval lines merely indicating its limits of free elastic rotation.

In fig. 1, at A, we have neutrality by the mutual attraction of each pair of molecules, being the shortest path in which they could satisfy their mutual attractions. At B we have the case of superposed magnetism of equal external value, rendering the wire or rod apparently neutral, although a lower series of molecules are rotated in the opposite direction to the upper series, giving to the rod opposite and equal polarities. At C we have the molecules arranged in a circular chain around the axis of a wire or rod through which an electric current has passed. At D we have the evident polarity induced by the earth's directive influence when a soft iron rod is held in the magnetic meridian. At E we have a longitudinal neutrality produced in the same rod when placed magnetic west, the polarity in the latter case being transversal.

In all these cases we have a perfectly symmetrical arrangement, and I have not yet found a single case in well-annealed soft iron in which I could detect a heterogeneous arrangement, as supposed by Ampère, De la Rive, Weber, Wiedemann, and Maxwell.

We can only study neutrality with perfectly soft Swedish iron. Hard iron and steel retain previous magnetisations, and an apparent external neutrality would in most cases be the superposition of one magnetism upon another of equal external force in the opposite direction, as shown at B, fig. 1. Perfectly soft iron we can easily free, by vibrations, from the slightest trace of previous magnetism, and study the neutrality produced under varying conditions.

If we take a flat bar of soft iron of 30 or more centimètres in length, and hold it vertically (giving while thus held a few torsions, vibrations, or, better still, a few slight blows with a wooden mallet, in order to allow its molecules to rotate with perfect freedom), we find its lower end to be of strong north polarity, and its upper end south. On reversing the rod and repeating the vibrations, we find

FIG. 1.

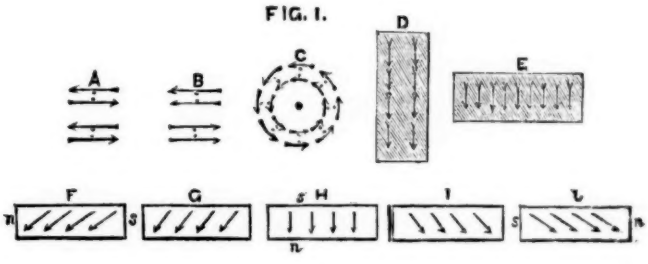


FIG. 2.

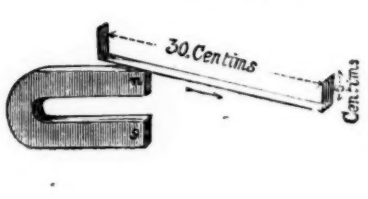
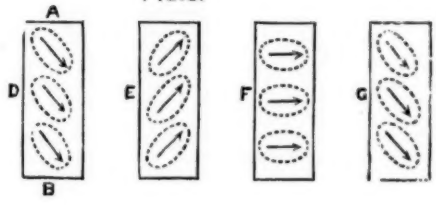


FIG. 3.



that its lower end has precisely a similar north polarity. Thus the iron is homogeneous, and its polarity symmetrical. If we now magnetise this rod to produce a strong south pole at its lower portion, we can gradually reverse this polarity, by the influence of earth's magnetism, by slightly tapping the upper extremity with a small wooden mallet. If we observe this rod by means of a direction needle at all parts, and successively during its gradual passage from one polarity to the other, there will be no sudden break into an haphazard arrangement, but a gradual and perfectly symmetrical rotation from one direction to that of the opposite polarity.

If this rod is placed east and west, having first, say, a north polarity to the right, we can gradually discharge or rotate the molecules to zero, and as gradually reverse the polarity by simply inclining the rod so as to be slightly influenced by earth's magnetism; and as no portion of this passage from one polarity to neutrality, and to that of the opposite name, will there be found a break of continuity of rotation or haphazard arrangement. If we rotate this rod slowly, horizontally or vertically, taking observations at each few degrees of rotation of an entire revolution, we find still the same gradual symmetrical change of polarity, and that its symmetry is as complete at neutrality as in evident polarity.

In all these cases there is no complete neutrality, the longitudinal polarity simply becoming transversal when the rod is east and west. F, G, H, I, J, fig. 1, show this gradual change, H being neutral longitudinally, but polarised transversely. If, in place of the rod, we take a small square soft iron plate and allow its molecules freedom under the sole influence of the earth's magnetism, then we invariably find the polarity in the direction of the magnetic dip, no matter in what position it be held, and a sphere of soft iron can only be polarised in a similar direction. Thus we can never obtain complete external neutrality whilst the molecules have freedom and do not form an internal closed circle of mutual attractions; and whatever theory we may adopt as to the cause of polarity in the molecule, such as Coulomb's, Poisson's, Ampère's or Weber's, there can exist no haphazard arrangement in perfectly soft iron, as long as it is free from all external causes except the influence of the earth; consequently these theories are wrong in one of their most essential parts.

We can, however, produce a closed circle of mutual attraction in iron and steel, producing complete neutrality as long as the structure is not destroyed by some stronger external directing influence.

Oersted discovered that an external magnetic needle places itself perpendicular to an electric current; and we should expect that, if the molecules of an iron wire possessed inherent polarity and could rotate, a similar effect would take place in the interior of the wire to that observed by Oersted. Wiedemann first remarked this effect, and it has been known as circular magnetism. This circle, however, consists really in each molecule having placed itself perpendicular to the current, simply obeying Oersted's law, and thus forming a complete circle in which the mutual attractions of the molecules forming that circle are satisfied, as shown at C, fig. 1. This wire becomes completely neutral, any previous symmetrical arrangement of polarity rotating to form its complete circle of attractions; and we can thus form in hard iron and steel a neutrality extremely difficult to break up or destroy. We have evident proof that this neutrality consists of a closed chain, or circle, as by torsion we can partially deflect them on either side; thus from a perfect externally neutral wire, producing either polarity, by simple mechanical angular displacement of the molecules, as by right or left-handed torsion.

If we magnetise a wire placed east and west, it will retain this polarity until freed by vibrations, as already remarked. If we pass an electric current through this magnetised wire, we can notice the gradual rotation of the molecules, and the formation of the circular neutrality. If we commence with a weak current, gradually increasing its strength, we can rotate them as slowly as may be desired. There is no sudden break or haphazard moment of neutrality, the movements to perfect zero are accomplished with perfect symmetry throughout.

We can produce a more perfect and shorter circle of attractions by the superposition of magnetism, as at B, fig 1. If we magnetise a piece of steel or iron in a given direction with a strong magnetic directing power, the magnetism penetrates to a certain depth. If we slightly diminish the magnetising power, and magnetise the rod in a contrary direction, we may reduce it to zero, by the superposition of an exterior magnetism upon one of a contrary name existing at a greater depth; and if we continue this operation, gradually diminishing the force at each reversal, we can easily superpose ten or more distinct symmetrical arrangements, and, as their mutual attractions are satisfied in a shorter circle than in that produced by electricity, it is extremely difficult to destroy this formation when once produced.

The induction balance affords also some reasons for believing that the molecules not only form a closed circle of attractions, as at B, but that they can mutually react upon each other, so as to close a circle of attractions as a double molecule, as shown at A. The experimental evidence, however, is not sufficient to dwell on this point, as the neutrality obtained by superposition is somewhat similar in its external effects.

We can produce a perfectly symmetrical closed circle of attractions of the nature of the neutrality of C, fig. 1, by forming a steel wire into a closed circle, 10 centimètres in diameter, if this wire is well joined at its extremities by twisting and soldering. We can then magnetise this ring by slowly revolving it at the extremity of one pole of a strong permanent magnet; and, to avoid consequent poles at the part last touching the magnet, we should have a graduating wedge of wood, so that whilst revolving it may be gradually removed to greater distance. This wire will then contain no consequent points or external magnetism: it will be found perfectly neutral in all parts of its closed circle. Its neutrality is similar to C, fig. 3; for if we cut this wire at any point we find extremely strong magnetic polarity, being magnetised by this method to saturation, and having retained (which it will indefinitely) its circle of attractions complete.

I have already shown that soft iron, when its molecules are allowed perfect freedom by vibration, invariably takes the polarity of the external directing influence, such as that of the earth, and it does so even with greater freedom under the influence of heat. Manufacturers of electro-magnets for telegraphic instruments are very careful to choose the softest iron and thoroughly anneal it; but very few recognise the importance as regards the position of the iron whilst annealing it under the earth's directing influence. The fact, however, has long since been observed.

Dr. Hooke, 1684, remarked that steel or iron was magnetised when heated to redness and placed in the magnetic meridian. I have slightly varied this experiment by heating to redness three similar steel bars, two of which had been previously magnetised to saturation, and placed separately with contrary polarity as regards each other, the third being neutral. Upon cooling, these three bars were found to have identical and similar polarity. Thus the molecules of this most rigid material, cast steel, had become free at red heat, and rotated under the earth's magnetic influence, giving exactly the same force on each; consequently the previous magnetisation of two of these bars had neither augmented nor weakened the inherent polarity of their molecules. Soft iron gives under those conditions by far the greatest force, its inherent polarity being greater than that of steel.

I have made numerous other experiments bearing upon the question of neutrality, but they all confirm those I have cited, which I consider afford ample evidence of the symmetrical arrangement of neutrality.

Superposed Magnetism.

Knowing that by torsion we can rotate or diminish magnetism, I was anxious to obtain by its means a complete rotation from north polarity to neutrality, and from neutrality to south polarity, or to completely reverse magnetic polarity by a slight right or left torsion.

I have succeeded in doing this, and in obtaining strong reversal of polarities, by superposing one polarity given whilst the rod is under a right elastic torsion, with another of the opposite polarity given under a left elastic torsion, the neutral point then being reached when the rod is free from torsion. The rod should be very strongly magnetised under its first or right-hand torsion, so that its interior molecules are rotated, or, in other words, magnetised to saturation; the second magnetisation in the contrary sense and torsion should be feebler, so as only to magnetise the surface, or not more than one-half its depth; these can be easily adjusted to each other so as to form a complete polar balance of force, producing, when the rod is free from torsion, the neutrality as shown at B, fig. 1.

The apparatus needed is simply a good compound horse-shoe permanent magnet, 15 centimètres long, having 6 or more plates, giving it a total thickness of at least 3 centimètres. We need a sufficiently powerful magnet, as I find that I obtain a more equal distribution of magnetism upon a rod or strip of iron by drawing it lengthwise over a single pole in a direction from that pole, as shown in fig. 2; we can then obtain saturation by repeated drawings, keeping the same molecular symmetry in each experiment.

In order to apply a slight elastic torsion when magnetising rods or wires, I have found it convenient to attach two brass clamp trees to the extremities of the rods, or simply turn the ends at right angles, as shown in the following diagram, by which means we can apply an elastic twist or torsion whilst drawing the rod over the pole of the permanent magnet. We can thus superpose several and opposite symmetrical structures, producing a polar north or south as desired, greatly in excess of that possible under a single or even double magnetisation; and by carefully adjusting the proportion of opposing magnetisms, so that both polarities have the same external force, the rod will be at perfect external neutrality when free from torsion.

If we now hold one end of this rod at a few centimètres distance from a magnetic directive needle, we find it perfectly neutral when free of torsion; but the slightest torsion right or left at once produces violent repulsion or attraction, according to the direction of the torsion given to the rod, the iron rod or strips of hoop-iron which I use for this experiment being able, when at the distance of 5 centimètres from the needle, to turn instantly 90° on either side of its zero.

The external neutrality that we can now produce at will is absolute, as it crosses the line of two contrary polarities, being similar to the zero of my electric sonometer, whose zero is obtained by the crossing of two opposing electric forces.

This rod of iron retains its peculiar powers of reversal in a remarkable degree, a condition quite different to that of ordinary magnetisation, for the same rod, when magnetised to saturation under a single ordinary magnetism, loses its evident magnetism by a few elastic torsions, as I have already shown; but when it is magnetised under the double torsion with its superposed magnetism, it is but slightly reduced by variations or numerous torsions, and I have found it impossible to render this rod again free from its double polar effects, except by strongly remagnetising it to saturation with a single polarity. The superposed magnetism then becomes a single directive force, and we can then by a few vibrations or torsions reduce the rod to its ordinary condition.

The effects of superposed magnetism and its double polarity I have produced in a variety of ways, such as by the electro-magnetic influence of coils, or in very soft iron simply by the directive influence of the earth's magnetism, reversing the rod and torsions when held in the magnetic meridian, these rods when placed magnetic west showing distinctly the double polar effects.

It is remarkable, also, that we are enabled to superpose and obtain the maximum effects on thin strips of iron from $\frac{1}{4}$ to $\frac{1}{2}$ millimetre in thickness, whilst in thicker rods we have far less effect, being masked by the comparatively neutral state of the interior, the exterior molecules then reacting upon those of the interior, allowing them to complete in the interior their circle of attractions.

I was anxious to obtain wires which would preserve this structure against the destructive influence of torsion and vibrations, so that I could constantly employ the same wires without the comparatively long and tedious process of preparation. Soft iron soon loses the structure, or becomes enfeebled, under the constant to and fro torsions requisite where we desire a constant change of polarity, as described later in the magnetic bells. Hard steel preserves its structure, but its molecular rigidity is so great that we obtain but mere traces of any change of polarity by torsion. I have found, however, that fine cast drill steel, untempered, of the kind employed by watchmakers, is most suitable: these are generally sold in straight lengths of 30 centimètres. Wires 1 millimètre in diameter should be used, and when it is desired to increase the force, several of these wires, say, nine or ten, should be formed into a single rod or bunch.

The wire as sold is too rigid to give its maximum of molecular rotation effect. We must therefore give it two entire turns or twists to the right, and strongly magnetise it on the north pole of the magnet whilst under torsion. We must again repeat this operation in the contrary direction, after restoring the wire to its previous position, giving now two entire turns to the left and magnetising it on the south pole. On restoring the wire to its original place, it will be extremely flexible, and we may now superpose several contrary polarities under contrary torsions, as already described.

The power of these wires, if properly prepared, is most remarkable, being able to reverse their polarity under torsion, as if they were completely saturated; and they preserve this power indefinitely if not touched by a magnet. It would be extremely difficult to explain the action of the rotative effects obtained in these wires under any other theory than that which I have advanced; and the absolute external neutrality that we obtain in them when the polarities are changing, we know, from their structure, to be perfectly symmetrical.

I was anxious to show, upon the reading of this Paper, some mechanical movement produced by molecular rotation, consequently I have arranged two bells that are struck alternately by a polarised armature put in motion by the double polarised rod I have already described, but whose position, at 3 centimètres distant from the axis of the armature, remains invariably the same. The magnetic armature consists of a horizontal light steel bar suspended by its central axle; the bells are thin wine glasses, giving a clear musical tone loud enough, by the force with which they are struck, to be clearly heard at some distance. The armature does not strike these alternately by a pendulous movement, as we may easily strike only one continuously, the friction and inertia of the armature causing its movements to be perfectly dead-beat when not driven by some external force; and it is kept in its zero position by a strong directive magnet placed beneath its axle.

The mechanical power obtained is extremely evident, and is sufficient to put the sluggish armature in rapid motion, striking the bells six times per second, and with a power sufficient to produce tones loud enough to be clearly heard in all parts of the hall of the society. As this is the first direct transformation of molecular motion into mechanical movement, I am happy to show it on this occasion.

There is nothing remarkable in the bells themselves, as they evidently could be rung if the armature was surrounded by a coil and worked by an electric current from a few cells. The marvel, however, is in the small steel superposed magnetic wire producing by slight elastic torsions from a single wire, 1 millimètre in diameter, sufficient force from mere molecular rotation to entirely replace the coil and electric current.

Elastic Nature of the Ether surrounding the Magnetic Molecules.

During these researches I have remarked a peculiar property of magnetism, viz., that not only can the molecules be rotated through any degree of any arc to its maximum, or saturation, but that, whilst it requires a comparatively strong force to overcome its rigidity or resistance to rotation, it has a small field of its own through which it can move with excessive freedom, trembling, vibrating, or rotating through a small degree with infinitely less force than would be required to rotate it permanently on either side. This property is so marked and general that we can observe it without any special iron or apparatus.

Let us take a flat rod of ordinary hoop-iron, 30 or more centimètres in length. If, whilst holding this vertically, we give freedom to its molecules by torsions, vibrations, or, better still, by a few blows with a wooden mallet upon its upper extremity, we find, as is well known, that its lower portion is strongly north, and its upper south. If we reverse this rod, we now find it neutral at both extremities. We might here suppose that the earth's directing force had rotated the molecules to zero or transversely, which in reality it has done, but only to the limit of their comparatively free motion; for if we reverse the rod to its original position, its previous strong polarity reappears at both extremities, thus the central point of its free motion is inclined to the rod, giving by its free motion great symmetrical inclination and polarity in one direction, but when reversed the inclination is reduced to zero.

In fig. 3, D shows the bar of iron when strongly polarised by earth's magnetic influence, under vibrations, with a sufficient force to have rotated its elastic centre of action. C shows the same bar with its molecules at zero, or transversal, the directing force of earth being insufficient without the aid of mechanical vibration to allow them to change. The dotted lines of D suppose the molecules to be in the centre of its free motion, whilst at C the molecules have rotated to zero, as they are prevented from further rotation by being at the extreme end of its free motion.

If, now, we hold the rod vertically, as at C, giving neutrality, and give a few slight blows with a wooden mallet to its upper extremity, we can give just the amount of freedom required for it to produce evident polarity, and we then have equal polarity, no matter which end of the bar is below, the centre of its free rotation here being perfect, and the rod perfectly neutral longitudinally when held east and west. If, on the other hand, we have given too much freedom by repeated blows of the mallet, its centre of free motion becomes inclined with the molecules, and we arrive at its first condition, except

that it is now neutral at D, and polarised at C. From this it will be seen that we can adjust this centre of action, by vibrations or blows, to any point within the external directing influence.

We can perceive this effect of free rotation in a limited space in all classes of iron and steel, being far greater in soft Swedish iron than in hard iron or steel. A similar phenomenon takes place if we magnetise a rod held vertically in the direction of earth's magnetism. It then gives greater polarity than if magnetised east or west, and if magnetised in a contrary sense to earth's magnetism it is very feebly magnetised, or, if the rod is perfectly soft, it becomes neutral after strong magnetisation. This property of comparative freedom, and the rotation of its centre of action, can be demonstrated in a variety of ways. One remarkable example of it consists in the telephone. All those who are thoroughly acquainted with electro-magnetism, and know that it requires measurable time to charge an electro-magnet to saturation (about $\frac{1}{10}$ of a second for those employed in telegraphy), were surprised that the telephone could follow the slightest change of timbre, requiring almost innumerable changes of force per second. I believe the free rotation I have spoken of through a limited range explains its remarkable sensitiveness and rapidity of action, and, according to this view, it would also explain why loud-sounding telephones can never repeat all the delicacy of timbre that is easily done with those only requiring a force comprised in the critical limits of its free rotation. This property, I have found, has a distinct critical value for each class of iron, and I propose soon to publish researches upon the molecular construction of steel and iron, in which I have made use of this very property as a guide to the quality of the iron itself.

The elastic rotation (in a limited space) of a molecule differs entirely from that known as mechanical elasticity. In perfectly soft iron we have feeble *mechanical* elasticity, whilst in tempered steel we have that elasticity at its maximum. The contrary takes place as regards *molecular* elasticity. In tempered steel the molecules are extremely rigid, and in soft iron its molecular elasticity is at its maximum. Its free motion differs entirely from that given it by torsion or stress. We may assume that a molecule is surrounded by continuous ether, more of the nature of a jelly than that of a gas: in such a medium a molecule might freely vibrate through small arcs, but a rotation extending beyond its critical limit would involve a much greater expenditure of force.

The discovery of this comparatively free rotation of molecules, by means of which, as I have shown, we can (without in any degree disturbing the external mechanical elasticity of the mass) change the axes of their free motion in any direction desired, has led me into a series of researches which have only indirectly any relation with the theory of magnetism. I was extremely desirous, however, of finding an experimental evidence which in itself should demonstrate all portions of the theory, and the following experiment, I believe, answers this purpose.

Let us take a square soft iron rod, five millimètres in diameter by 30 or more centimètres in length, and force the molecules, by aid of blows from a wooden mallet, as previously described, to have their centres of free motion in one direction, the rod will (as already shown) have polarity at both ends, when held vertically; but if reversed both ends become completely neutral.

If now we turn the rod to its first position, in which it shows strong polarity, and magnetise it whilst held vertically, by drawing the north pole of a sufficiently powerful permanent magnet from its upper to its lower extremity, we find that this rod, instead of having south polarity at its lower portion as we should expect from the direction of the magnetisation, is completely neutral at both extremities; but if we reverse the rod its fullest free powers of magnetisation now appear in the position where it was previously neutral. Thus, by magnetisation, we have completely rotated its free path of action, and find that we can rotate this path as desired in any direction by the application of a sufficient directing power.

If we take a rod as described, with its polarities evident when held vertically, and its neutrality also evident when its ends are reversed in the same magnetic field, we find that its polarity is equal at both ends, and that it is in every way symmetrical with a perfect magnet. If we *gradually* reverse the ends and take observations of its condition through each degree of arc passed over, we find an equal symmetrical diminution of evident external polarity until we arrive at neutrality, when it has no external trace of inherent polarity; but its inherent polarity at once becomes evident by a simple return to its former position. Thus the rod has passed through all the changes from polarity to neutrality, and from neutrality to polarity, and these changes have taken place with complete symmetry.

The limits of this paper do not allow me to speak of the numerous theoretical evidences as shown by the use of my induction balance. I believe, however, that I have cited already experimental evidences to show that what has been attributed to coercive force is really due to molecular freedom or rigidity; that in inherent molecular polarity we have a fact admitted by Coulomb, Poisson, Ampère, De la Rive, Weber, Du Moncel, Wiedemann, and Maxwell; and that we have also experimental evidence of molecular rotation and of the symmetrical character of polarity and neutrality.

The experiments which I have brought forward in this paper, in addition to those mentioned in my paper read before the Royal Society, will, I hope, justify me in having advanced a theory of magnetism which I believe in every portion allows at least experimental evidences of its probable truth.

Physical Society—May 26th.

PROFESSOR CLIFTON in the chair.

MR. G. GRIFFITH read a paper "On the Graphical Representation of Musical Intervals," in which he gave an account of previous attempts to represent musical intervals in a graphical manner, and exhibited an enlargement of a diagram published by Dr. Pole in Sir F. Ouseley's "Treatise on Harmony." In this diagram the musical intervals contained in one octave are represented by the differences between the logarithms of the vibration numbers forming them. Mr. Griffith proposes to apply the principle to the whole musical scale. Retaining the lines used in ordinary music he inserts a faint line between these at unequal distances to represent the tones and semi-tones. Several diagrams were exhibited in which this principle was applied to the representation of intervals to the sequence of the keys in the major diatonic scale and to actual music.

Mr. W. G. BLAKELY and Dr. COFFIN considered that it would be a great help to students to have the method proposed. Mr. BLAKELY considered that it combined the advantages of the Tonic Sol-fa and ordinary notation. Dr. COFFIN thought that it might become generally used.

A paper, by DR. J. FLEMING, on a "Phenomenon of Molecular Radiation in Incandescence Lamps." When the carbon filament in an Edison lamp volatilises the vapour is condensed on the glass in a cloud. When the copper electrode is volatilised the copper is likewise deposited, but there is a bare space or line left on the glass in the plane of the filament, forming, as it were, a shadow of the filament. Dr. FLEMING explains this on the supposition that the copper particles are thrown off in straight lines, as in a Crookes' vacuum. This shadow is not noticed in the carbon deposits. Dr. FLEMING also remarks that the colour of a thin copper conch is the same as a thin layer of gold in transmitted light.

Mr. W. BAILY read a paper "On an Illustration on the Crossing of Rays." He took the case of three rays of homogeneous light of the same intensity and parallel to one plane, and polarised so that the vibrations were also parallel to the plane, and he exhibited and explained diagrams showing the motion which would occur under the circumstances. Prof. F. GUTHRIE exhibited one of Cheadin's plates, bearing a striking resemblance to one of these figures. Mr. BAILY thought the analogy might be a real one.

Prof. CLIFTON described an improvement which he had made in the glass insulating stem he had exhibited to the Society on a former occasion. This stem had a glass cup encircling it, and of a piece with the stem. Sulphuric acid was put into the cup. The new pattern had a hole formed into the bottom of the cup, and the upper part of the stem fitted into this hole like a stopper. It could then be removed at will, and the acid renewed. Prof. AYRTON stated that he had used a similar arrangement for nearly two years, a narrow necked glass bottle taking the place of the cup.

TO CORRESPONDENTS.

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CORRESPONDENCE.

Incandescence Lamps.

Permit me to say that you appear somewhat to have misunderstood my remarks in your last week's issue. My contention is simply this, that as a matter of fact the average incandescence of Swan lamps in actual practice is not higher than that of Edison lamps, although

owing to the form given to the carbon it appears to be so. This can be readily verified by examining the carbons of the respective lamps when burning through a piece of cardboard, with a slit allowing only about one-eighth or one quarter of an inch of luminous carbon to be visible at once. Of course the higher the incandescence the more economical the light production; but after a certain brilliancy has been attained this is counterbalanced by the cost of renewals arising from the rapid destruction of carbons. I adhere to my belief that the Swan lamp has not proved itself to be more economical than the Edison, taking into account the cost of power and renewals, and assuming the price of the two lamps to be equal. Indeed, so far as comparative tests which have been made public are concerned, the advantage is decidedly in favour of the Edison lamp. It may be very well to speak of ten lamps of 20 candles per indicated H. P., or per effective H. P., on paper; but I am afraid Mr. Crompton will find the consumption of coal or gas will not work out to this figure. If he gets ten lamps he will not get 20 candles *actual*, and if he gets 20 candles he will not get ten lamps with an average life of 1,000 to 1,200 hours each.

Continuous Current.

Tests of Incandescent Lamps.

In response to your note attached to my letter of the 12th May, and which, owing to my absence from London, I have been unable to reply to before, I have pleasure in stating that the instruments used in making the tests were an Ayrton and Perry voltmeter, freshly calibrated, and Sir William Thomson's patent current galvanometer; these instruments are tested and checked from time to time with a Siemens voltmeter and Siemens dynamometer. The candle-power was taken with a Rumford photometer, so that the tests can be taken as correct, and have been verified again.

In reply to Mr. F. H. Varley's letter on the same subject, in your issue of the 26th May, I have had the resistance of these lamps taken when cold, and also when burning at 20 candle-power, by Crookes' Wheatstone bridge method. The two lamps, taken at random from the special batch of 15 tested before, give:—

Resistance cold.	Resistance at 20 candle-power.
100 ohms	47·0 ohms
97 ,,	46·5 ,,

This would make the current by calculation 1·04 and 1·05 ampères respectively. The tests showed the current to be 1·05 ampères; the resistance tests therefore entirely confirms the original current tests.

Mr. Varley's constant ·55 should with these Gatehouse lamps be changed to ·475; probably, however, this latter constant would require to be altered for other Gatehouse lamps.

Perhaps there are other of your readers interested in incandescent lighting who can tell us of similar advances; it appears to me that 15 lamps of 20 candle-power for about one electrical H. P., each lamp taking only 50 watts, is a decided advance, and will materially reduce the cost of incandescent lighting.

I hear from Messrs. Woodhouse & Rawson that they have recently made incandescent lamps which give 20 candle-power with about 60 watts. This result, although very excellent, is not so good as I have shown.

Henry F. Joel, C.E.

London, 6*th June*, 1883.

Secondary *v.* Primary Batteries for Temporary Electric Light Installations.

I read in your last issue an article upon primary batteries, but regret that I cannot agree with the substance of it.

Zinc has not yet been replaced by a cheaper substance in primary batteries, and as long as it is used they can never, even for temporary installations, become useful sources of energy, either for lighting or power.

From my own experience in temporary lighting I have found nothing better than secondary batteries, though I was once, like many others, a sceptic; but since I have used them, and seen them efficient even after twelve months' use, I am certain that they cannot be excelled by any other method of producing electricity for temporary lighting or power. I have made several temporary installations in electric lighting by means of the Faure-Sellon-Volckmar accumulators; for example, on the occasion of a ball at a private house in Pembridge Crescent, Bayswater, where a marquee was brilliantly lighted by incandescent lamps, the power being furnished by thirty 1 horse-power accumulator cells which were lent at a reasonable charge by the Electrical Power Storage Company. These cells were fixed and the leads and lamps arranged in a few hours, and were quite out of sight in the garden; although if there had been room they need not have been removed from the cart which brought them. The charging of the cells and the cartage cost but a few shillings, whereas in the case of primary batteries I am confident that it would have cost as many pounds.

The light was perfectly maintained for ten hours, and there was still a residue of energy sufficient to have furnished another hour of good light had it been required.

The accumulators and all the apparatus, wires, &c., were away by ten o'clock on the following morning, and I do not think that a temporary installation could be managed better or cheaper.

My own experience has proved to me that the accumulators made by the Electrical Power Storage Company are a really good commercial article, the only disadvantage attending their use being the high price of the cells. Many users of light and power would make use of accumulators if they were within their means, but this will, I hope, be modified in time.

G. Binswanger.

29, Aldermanbury, E.C., *June 6th*, 1883.

Ayrton and Perry's Motor.

At the last Cantor lecture this season I exhibited to the Society of Arts a compact "½-horse" motor which Profs. Ayrton and Perry had been good enough to lend, applying to it an E.M.F. of about 60 volts from 29 Faure-Sellon-Volckmar cells, but I was able to stop the motor with one hand. This apparent failure of the machine was due to a resistance coil which had been added to it in order to prevent its racing itself to pieces when it was doing no work. By some oversight I had not been informed of the existence of this resistance, and consequently I did not remove it when testing the power of the machine. Under these circumstances it is not surprising that it refused to work as well as the De Méritens motor, which had no such artificial obstruction between it and the battery. I think it only fair to the patentees of the motor to make this explanation of an occurrence which they fear might otherwise have a damaging effect.

Oliver J. Lodge.

University College, Liverpool,
May 30th, 1883.

Electric Lighting.

In reading over the particulars for the lighting of portions of the municipal buildings, Leeds, I notice that "The tenders must provide for the employment of the Crompton-Bürgin dynamo-machines for both the arc and incandescent lamp lighting."

Would it not be well if you were to call attention to this most absurb stipulation in your valuable journal? Surely one ought to choose his own dynamo to suit his own purpose. I have tried a number of experiments with Bürgin machines, and do not think they are anything like so efficient as the Gramme or Siemens. Mechanically the Bürgin machine is very good, but electrically it is not efficient, as it takes far too much "driving."

For some time past I have had a 4 H. P. vertical engine by Marshall & Sons, which I used for experimenting. I can only work four or five of my lamps from a Bürgin machine (B) with 80 lbs. of steam pressure (five at the most), but I can do *eight lamps* of equal candle-power from the same engine with 70 to 80 lbs. of steam. Besides the price of such a Gramme is only about the same as the B Bürgin. I have also had more hot bearings in my Bürgin machines than in my Grammes.

Charles Lever.

May 28th, 1883.

[Mr. Lever was perfectly right in calling attention to the stipulation mentioned concerning the electric lighting of Leeds.* An esteemed contemporary commented on this matter in the following terms:—

"It is certain that neither Messrs. Siemens Bros., the Edison, or the Brush Companies will entertain this proposition, and enter upon a risky contract for the purpose of pushing the machines of a rival manufacturer. . . . We think that the committee has been ill advised in thus rejecting the generators of other firms whose reputation in that branch stands at least as high as that of the Swan United."

These remarks may have had some effect on the Leeds committee.

Mr. Lever's experience with the machines quoted may not be that of others, but in the absence of really authoritative tests, it is scarcely politic for us to express an opinion.—EDS. ELEC. REV.]

The time is drawing near when the various competitors for public favour in electric lighting will either be accepted by the Board of Trade under Provisional Orders, or have the licences accorded by the local authorities confirmed by the presiding power at Whitehall. It may therefore be well to pass in review the operations contemplated by, and results likely to proceed from the two courses which lay open to the companies engaged in lighting by the new method.

Under the "Act" there are three plans:—

1st. A parish or local authority can apply for a licence for themselves.

2nd. Parishes or local boards can grant to a company permission to apply for a licence.

3rd. An electric company can apply to the Board of Trade for Provisional Orders.

The 1st and 2nd methods are the legitimate modes of procedure, the 3rd I venture to consider irregular, and the Board of Trade in framing the Act went too far in advance of science. There is no doubt that to proceed by application for a licence was the right course for the companies to adopt, leading the vestries by silk, not employing the "halter."

In many instances vestries and boards are greatly disgusted and annoyed at the action of certain light companies, and will doubtless offer strenuous opposition to the introduction of "compulsory orders." At the same time many of the vestries are to blame for putting off until the last moment their decision regarding applications for licences, thereby allowing those companies proceeding on the lines of Provisional Orders to have advantages accorded to them which they never should have had.

The conduct of some of the light companies has also been highly reprehensible. Before the "Act" was an hour old some of these companies had scheduled London under Provisional Orders, knowing that they had neither the "system," nor the means for carrying out one tithe of what, in their greed, they were desirous of undertaking.

One of the arguments brought by companies applying for Provisional Orders against those who thought right to seek a licence, is, that the latter are not warranted in asking for same on the short tenure of

* See our "Notes" columns of last week.

seven years; to this I would remark, if a company, under a licence, do their work efficiently, and to the satisfaction of the Board, the renewal of that licence is all but a certainty, whereas, a company obtaining Provisional Orders, though nominally, their lease is twenty-one years, inability to perform the work undertaken, to the satisfaction of the vestry, will necessitate their expulsion in two years. Viewed therefore in all its bearings, I consider the licence as before said, the proper and legitimate application to make, more commercial, and more to the benefit of both Local Authorities and Electric Light Companies, enabling the former at the expiry of the term to suggest and arrange for the improvements which must necessarily follow, the latter, to modify the terms which they undoubtedly will be able before long to do, as the price of materials necessary for carrying out electric lighting in all its varied branches, cannot, as before said, fail to become considerably reduced in cost.

In conclusion I may remark, that up to the present time, the only "company of note" that has applied for a licence is the one which first made electric lighting practical, and which has for years conducted lighting, both public and private, to the satisfaction of all those who have tried it and who have never, as far as I can learn, had the "system" turned out where once installed. This company's action in the matter of licences proves the soundness of its views and the business-like lines along which it has always endeavoured to move.

Electron.

May 28th, 1883.

"The Ablest Electricians Living To-day."

I hasten to ask that you will afford a much-needed consolation by giving an assurance—in leader type—that Sir William Thomson, Professor Hughes, C. F. Varley, Professor S. P. Thompson, Robert Sabine, Sir C. W. Siemens, W. H. Preece, Willoughby Smith, Sir Charles Bright, Professors Ayrton and Perry, Edward Graves, Latimer Clark, Edward Crompton, Graham Bell, C. F. Brush, Thomas Alva Edison, and Robert Hammond, all recognised electricians, *are really* "LIVING TO-DAY," as otherwise, from Mr. N. de Kabath's letter, which you published the week before last, many might mourn their loss, seeing that it is implied that they have all gone over to the great majority, and left but Messrs. Weston and Maxim "the ablest electricians—*living to-day*."

Of course, Swan *may* exist, Crookes remain in vacuity, Lane-Fox wriggle enough to show he is not defunct, and Fitzgerald just splutter, but as for actual *living* electricians of to-day, are there, can there be any left, after that one annihilating sentence of extinguishment?

Not One of the Ablest.

Metal Microphones.

Will you kindly allow us to show that Mr. Munro is mistaken in more than one sense when he says that we did not even dream that Edison patented in 1880 the use of "the very metals" for microphone contacts which we name in our own specification of March 4, 1882?

A careful perusal of Edison's specification and of our own will show:—

1. That Edison *has not patented* the use of "the very metals we mentioned ourselves."

2. That we *were* acquainted with Edison's specification when we drew up our own.

The provisional specification of this 1880 (No. 5,113) patent of Mr. Edison's is a most remarkable composition, and looks very much like an attempt to patent both what *had already* been invented by others and what would still *have to be* invented by others.

It must be evident to any electrical reader of this provisional specification that Mr. Edison never could have wasted his time in moulding sticks of "powdered borax" (*sic!*), or buttons of "powdered eubium," or, again, discs of "powdered glucinum," to form his tension-regulators, and that this most formidable list of some hundreds of substances (necessarily including the names of the "very metals" we mention in our own patent) is almost entirely of a speculative nature. At all events, Mr. Edison did not perpetrate it again in his final specification, but confined himself to sticks and buttons of carbon.

It will be found that we referred to Edison's sticks and buttons moulded from powdered metals and metalloids in our patent of March 4, 1882, and pointed out the difference between our contacts and Mr. Edison's.

This explanation does not arise from any desire on our part to be considered the first and only successful workers in the direction of "elementary" metal microphones.

On the contrary, we beg here to mention that at the very same time when we experimented with tellurium in this country, Mr. E. H. Johnson did the same thing in America, and even filed a patent for a tellurium transmitter some two months before we did. The nature of Mr. Johnson's transmitter was, however, still a secret when we had sealed our patent, and when Mr. Johnson allowed his patent to lapse, ours was not affected by the priority of his.

Mr. Munro is quite right when he thinks that the fibrous vibrator which we use in our metal microphone transmitter has a good deal to do with the successful working of the latter.

Indeed, it was not until we abandoned tympans and diaphragms and reduced the amplitude of vibration, that we succeeded with the metal transmitter.

R. & M. Theiler.

London, *May 29th*, 1883.

Why Cable Companies don't pay.

When the immortal Shakspeare penned these words: "I'll put a girdle round about the Earth in forty minutes," he had an idea that such prophetic words would in the nineteenth century become a *fait accompli*, but we think he would have hesitated in making this assertion if he could have studied the consequences and the cost. But the melancholy picture presented by their chairman on the 23rd ultimo, to the shareholders of the West India and Panama Company must have had a very depressing effect upon the most inveterate dabbler in cable shares, and there must have, in our opinion, been few indeed who left the Cannon Street Hotel with a blessing on this "Girdle of the Earth." The chairman was lavish in his lamentations in respect of the company's affairs and gave three very good reasons for the poverty of this unfortunate undertaking. The capital seems to have been subscribed through a rose-coloured or garbled prospectus; the colonists seem not to sympathise with the company in their disinterested endeavours to please them, and Lord Derby, as Colonial Secretary, treats the deputation of directors with courtesy but does not hold out any hope of being able to ameliorate the present unenviable position to which the shareholders have now to submit. No doubt Mr. Earle and his colleagues on the Board of Direction have large sympathies with the shareholders, but unfortunately their commiseration failed to take a tangible form and they were not prepared to forego any portion of their fees towards paying a small, a very small dividend, or even to inaugurate a deserving charity which might be named the "Ruined Shareholders' Relief Fund."

Now that the chairman of the West India and Panama Company has shown by the light of his electric knowledge some of the causes which have contributed to the troubles of his company, the present time may be opportune for saying a few words upon the misfortunes of cable companies generally and "why cable companies don't pay."

To deal with this question *ab initio* it will be necessary to lay it down as an axiom "that submarine cables are not laid generally to meet any pressing or public want." There are such enterprises known as cable manufacturing companies, some of which, through their success in one or two ventures, have been enabled to pay high dividends, and even to return a portion of the subscribed capital; but having expended large sums on plant, and having a large staff of officers and men to provide for, must find new fields for their operations. It matters little whether it is to Madagascar, New Guinea, or Pitcairn's Island, a cable must needs be submerged to keep all hands employed. Having obtained the necessary concession, which is not always obtainable without considerable expense, a few names must be got together, especially those who know nothing of telegraph business, but who either through being titled gentlemen or from their financial position inspire confidence in the "widow and orphan," which has become a stock phrase with the philanthrophic promoters of companies, and these gentlemen become directors of the company. So far so good, for these gentlemen who have been induced to take a seat at the board must busy themselves in inducing their friends, generally relatives, to take shares, and the prospects of the concern seem beyond question, seeing that Lord So-and-So and Sir Somebody are included in the directorate. Then comes the highly-coloured prospectus. It gives the population of the country or district to which the promoters of the company purpose giving the benign and civilising blessing of cable communication, and after stating, for the information of doubting dupes, the resources of that part of the world—it matters not where—they give figures which show that if so many persons send so many messages at so much a word, it would be equivalent to a dividend of at least twenty per cent., which doubtless would be largely augmented as the resources of the country became better known! This is another great enticement to a man who has put past a little of his hard-earned savings to invest them in a new cable scheme. He reads in the prospectus that the contractors for the cable have taken two or three hundred thousand pounds in shares in the new company as part payment for the manufacture and laying of the cable, as a guarantee that they have every confidence in the undertaking. Telegraph investors, do not be deceived. Whenever a cable manufacturing company accept shares in part payment, depend upon it that the shareholders have ultimately to pay much more than the cable is really worth. If our principal submarine cables had been paid for in cash, there are few of them which might not now be earning an honest dividend for their shareholders. We now assume that the cable has been laid and has been working satisfactorily for a year or two. The shareholders now begin to look with an anxious eye for the twenty per cent. dividend which occupied so prominent a position in the prospectus, but which now is conspicuous by its absence. The shareholders are called together and the directors will tell them the reasons why their expectations have not been realised. They will be told that the falling off in the receipts is caused through the dullness, perhaps, in the dried meat trade, or that the crops have been destroyed through a visitation of locust, or perchance that the cable has frequently been interrupted through fish-bites. The explanation is considered satisfactory, and the shareholders who came to the meeting to curse go home to pray for better luck next time. Now it becomes apparent to those who compose the "Telegraph ring," that there is little chance of any dividend on the ordinary shares, and the directors are strongly advised to issue debentures on preference shares, and these are chiefly taken up by friends of the board and the contractors, who thus obtain a real security not unfrequently by exchanging the ordinary shares, which are practically valueless. It is deplorable to think that within the last ten years there have been so many millions of capital lost, and in several cases the capital of the companies has been depreciated fifty or even more than fifty per cent. If investors were a little more conversant with the mysteries of telegraph management they would abstain from purchasing cable stock instead of looking upon every new scheme as a veritable Eldorado. If investors must have telegraph shares they should be careful that the directors are gentlemen who have a direct interest in the undertaking, and not others, for no matter who should be sent empty away, the professional director must find a *modus vivendi*.

Argentina.

The Telephone.

Can you, or some of the readers of your periodical, kindly tell me where to find a description (if possible an illustrated one) of the Lockwood, Bartlett and Barney telephonic apparatus? I don't remember to have seen it in your numbers.

T. W. G.

Delft, *May 22nd*, 1883.

[See ELECTRICAL REVIEW, p. 358, Sept. 15th, 1881; p. 354, Nov. 4th, 1882; p. 408, June 3rd, 1882; and p. 324, Oct. 21st, 1882. EDS. ELEC. REV.]

The Maxim-Weston Electric Light Company.

Kindly allow me to refer to the account, published in your issue of the 26th, of the last general meeting of the Maxim-Weston Electric Company, and to Mr. Hugh Watt's characteristic statement that the late secretary of the company (myself) had furnished him, in a letter dated July 10th, with information on which he based certain extraordinary calculations of profit and loss which he had made in a circular he had recently issued to some of the shareholders of the company, and which calculations—and also the circular itself—were repudiated by the chairman on behalf of himself and the rest of the board of directors.

I only wish to say that the figures given by Mr. Watt are absurd, impossible, and untrue, and cannot therefore be correctly based upon any information furnished to him even so long ago as July 10th.

F. H. Landon.

Woodford Wells, Essex, *May 28th*, 1883.

Electrical Measurements.

Referring to the correspondence in your columns (issues March 10th, May 5th and 19th) on the measurement of the E.M.F. and resistance of a battery in one operation by the metre bridge, a numerical example may be of interest. The bridge employed was of the half-metre form and the slide-wire an alloy of platinum of ·71 mm. diameter, and resistance ·41 ohm. The standard cell was a Daniell, and five Fuller's were to be measured. The adjustable resistance in the branch was varied from 0 to ∞, but no balance could be obtained. The test was therefore taken by the ordinary bridge method (devised by Mr. J. J. Fahie) and the E.M.F. of the five cells (E) found to be 10·88 volts and their resistance (ρ) 22·7 ohms. From the data thus obtained it could be readily seen why the slide-wire test was impossible in this case.

First, let the adjustable resistance (r) be nil, then the potential at the positive pole of the larger battery, which must be made equal to the E.M.F. of the standard (e = 1·079 volts) in order to get a balance, would be—

$$E \frac{R}{\rho + R} = \cdot 19 \text{ volts},$$

where R = resistance of slide-wire.

Thus equilibrium is not obtained, and it is evident cannot be secured by any increase of r, since by its addition the difference of potential becomes

$$E \frac{R}{\rho + R + r} \text{ volts},$$

a result, of course, less than the former.

The conditions necessary to obtain the balance would be—

$$E = e \frac{\rho + R}{R} \text{ volts } (\rho \text{ being constant}),$$

or,

$$\rho = R \frac{E - e}{e} \text{ ohms } (E \text{ being constant}),$$

which is impossible for one or n cells in series.

Or again, a standard cell of lower E.M.F. could be used; or better still, a resistance added to the slide-wire which, *per se*, having so low a resistance, has not sufficient difference of potential between its terminals to balance the standard. It would, however, be necessary to express this added resistance in terms of the length of the slide-wire (by Hockin's method, or proportion). This latter method I tried and obtained the balance, but the resistance necessary in each case was below 2 ohms, an objection in battery tests. In the ordinary metre form of bridge, in which the wire is generally of German silver and about 1½ mm. diameter, its resistance would be even lower (about ·12 ohm).

On the other hand, I find (with Mr. Purnell) that the same method adapted to any ordinary resistance box or bridge (by Mr. Fahie) is very rapid and reliable.

H. D. Wilkinson.

School of Electrical Engineering, 12, Prince's Street, Hanover Square, W.

Secondary Generators.

Having some experience in working a system of my own for producing lights in vacuo by means of secondary currents, I should wish to notice a few interesting experiments which go far to show the economy, or non-economy, of such currents applied to lighting; I shall, therefore, simply describe the experiments, the results speak for themselves.

In the first case I used a Siemens alternate current dynamo, D, in fig. 1, with its exciter. This was coupled up direct through ten or twelve Maxim, L, lamps, and through a large induction coil, I, so that all the current passed first through the lamps then through the primary wire of the induction coil.

This induction coil had a movable core, and when the dynamo was started and the current turned on for the first experiment, the core was out of the coil altogether. *The Maxim lamps were then brilliantly incandescent.* The speed of the dynamo was now taken and found to be 700 rev. per min.

Now the core of the coil was inserted gradually into the coil, and as more and more of the core entered the coil the incandescence of the Maxim lamps became less and less until finally, *when all the core was in its place, the Maxim lamps gave no light at all*, yet the dynamo still ran at 700 per minute.

The insertion of the core evidently set up a counter E.M.F. to the E.M.F. of the dynamo, and thus reduced the current. For this reason it is impossible to obtain a current from an alternate current dynamo through large electro-magnets. I coupled up this alternate current dynamo to the field-magnets of a large dynamo, and although the alternate current dynamo was powerfully excited and running at 800 revolutions per minute, the current which it could produce through the field-magnet coils (the total resistance of which was under 2·5 ohms) was too small to be measured.

This is all well-known perhaps, but it does not seem to be remembered sometimes in dealing with alternate currents. However, we may assert that a counter E.M.F. is set up in a coil of wire carrying an alternate current and wound upon an iron core, and this E.M.F. is proportionate to the size of the iron core and the length of wire in the coil surrounding the core.

Dr. Hopkinson proposes to regulate the strength of alternate currents by this means. He takes a Gramme ring with a very large core and arranges the ends of the sections of wire so that he can introduce more or less of it into the circuit. Evidently regulation could be obtained by sliding a core out or into a coil of wire in circuit. One great advantage such methods of regulation have over all others —*they do not waste energy.*

The next experiment was to join the ends of the secondary wire, S, T, fig. 1. In the first experiment the secondary wire had been idle, but in this second experiment everything remained the same as in fig. 1, the core being out and *the ends of the secondary wire joined directly together.* On running the dynamo now at 700 the Maxim lamps were again brilliantly incandescent, *and on introducing the core they were but very slightly reduced in brilliancy.*

Evidently the joining of the secondary wire terminals had a powerful effect, as was shown to be the case *upon breaking the secondary circuit when the Maxim lamps became a dull red, giving no light*, and thus by merely *making* the secondary circuit I could turn up the light to brilliancy, and by breaking the secondary circuit I could turn the lights down to a dull red.

This experiment shows very clearly the action of secondary generators, and beautifully illustrates the fact that secondary generators have a counter E.M.F. set up in their primary circuit, *and that the secondary currents generated in the secondary wire of such generators* in their turn *neutralises this counter E.M.F.*

Now these phenomena indicate a vast objection—or, rather, obstacle —in the way of the distribution of electric lights by secondary generators, because, although the main current is beyond the reach of the hand, or of any instrument, it can be reduced to nothing or increased to its maximum without in any way interfering with the wires or coils conveying it.

Suppose a series of seven secondary generators in series (fig. 2), an alternate dynamo, D, sends current through the primary wires of each generator, and all the secondary wires to be open circuit; in this case the counter E.M.F. would be so great that very little current would pass through the series. Now join up, *a*, generator

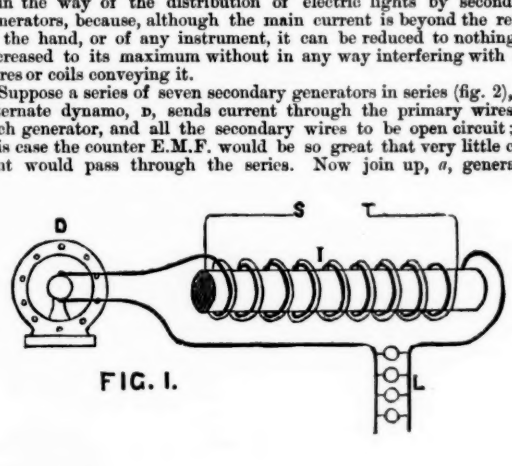

FIG. 1.

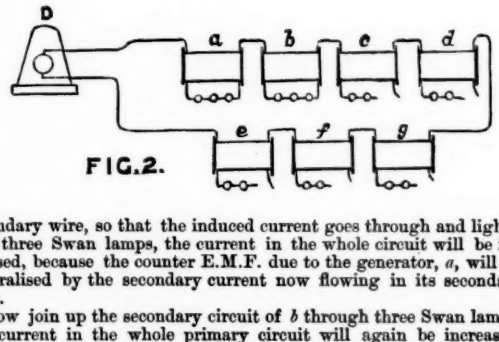

FIG. 2.

secondary wire, so that the induced current goes through and lights, say, three Swan lamps, the current in the whole circuit will be increased, because the counter E.M.F. due to the generator, *a*, will be neutralised by the secondary current now flowing in its secondary wire.

Now join up the secondary circuit of *b* through three Swan lamps, the current in the whole primary circuit will again be increased, because the counter E.M.F. of *b* will now be neutralised, and so on. Every generator's secondary circuit on being closed would affect the current in all the others, and this without any metallic or other connection whatever between the several secondary wires or between the secondary and primary wires.

In parallel arc, however, the secondary generator is a beautiful self-governing system of distribution; but what about the size of conductors for such a system? Prodigious!

Rankin Kennedy,
Electrician.